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# Resilience at UMass Amherst: A Sustainable Sites Initiative Inspired Master's Project

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## RESILIENCE AT UMASS AMHERST

*A Sustainable Sites Initiative inspired  
Master's Project by Nelle Ward*



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Master's Project by Nelle Ward*



Department of Landscape Architecture & Regional Planning  
University of Massachusetts Amherst  
September, 2016

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# ABSTRACT

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A new movement to plan and design monitorable green stormwater infrastructure is beginning to emerge. Faced with the imminent effects of climate change, “sustainability” is becoming a more important part of municipal long-term planning and design strategies. Accumulating evidence demonstrating the myriad of environmental and aesthetic of green stormwater infrastructure (GSI) has given rise to programs that offer sustainability guidelines such as the Sustainable Sites Initiative (SITES) guidelines. SITES encourages resilient landscapes that are designed to: maximize ecosystem service benefits, be monitored for benefits or lack thereof, provide educational opportunities, and improve human health and well-being. In using these wholistic guidelines on a range of projects at multiple scales, municipalities may develop resilient and responsive sustainable landscape practices, in which the ecological management of stormwater plays a critical role. This master’s project proposes that the University of Massachusetts Amherst pilot an ecosystem-service based green stormwater infrastructure demonstration site and educational platform in front of the Fine Arts Center, utilizing the SITES guidelines to explore monitoring methods that could provide useful data for future campus GSI planning initiatives.



CHAPTER 1

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INTRODUCTION





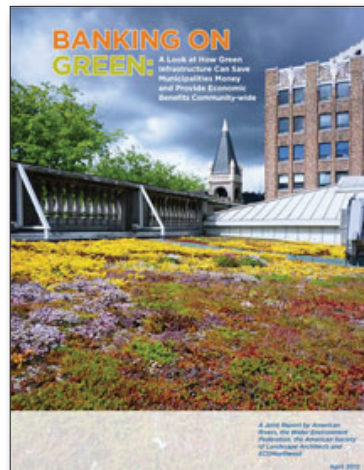
# INTRODUCTION

Over the past decade, increased regulatory pressure and financial costs associated with stormwater management has caused municipalities to re-evaluate conventional stormwater management methods. A major impetus in the U.S. stems from the EPA's response to the nation's increasingly threatened water supply: an updated set of regulations that puts pressure on municipalities to incorporate the use of green infrastructure into municipal stormwater management plans. Green stormwater infrastructure uses natural ecosystem service processes to infiltrate, remediate, and/or recycle stormwater runoff close to its source, while providing environmental, economic, and social beneficial byproducts (Carlson et al., 2014). GSI "often uses vegetation, engineered soils, and permeable surfaces to intercept stormwater before it reaches the wastewater system, reducing the burden on the grey infrastructure system, limiting the amount of polluted stormwater runoff entering waterways, and reducing the number and volume of combined sewer overflows" (p. 2). GSI usually complements rather than replaces existing grey infrastructure; GSI may be linked to existing sewer and stormwater systems. GSI can improve the ecological integrity of receiving waterbodies, recharge groundwater, remove harmful pollutants, reduce flooding, sequester CO<sub>2</sub>, improve air quality, reduce the urban heat island effect, provide green space and habitat for wildlife, and provide shade (Carlson, et al., 2014).

While peer-reviewed research has thoroughly documented these benefits, and preliminary results of municipal GSI performance monitoring programs have been generally promising, due to a general lack of concrete evidence based on performance monitoring in the field, municipalities have been slow to spend public money on massive, expensive stormwater management system overhauls. Because municipalities must nonetheless respond to the EPA's regulations, an interest in designing green stormwater infrastructure (GSI) that can be tested and monitored for some of these benefits is beginning to emerge.



City vision for Philadelphia: [http://www.phillywatersheds.org/what\\_were\\_doing/green\\_infrastructure](http://www.phillywatersheds.org/what_were_doing/green_infrastructure)

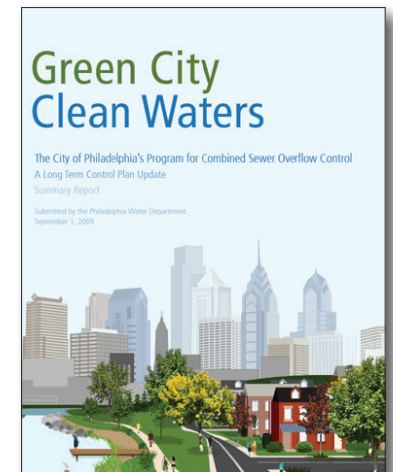


Released by American Rivers in collaboration with the American Society of Landscape Architects, ECONorthwest and the Water Environment Federation in April 2012



Released by PlaNYC; NYC Environmental Protection; mayor Bloomberg in 2010

Released by Philadelphia Water Department, ammended June 2011



Programs such as the Sustainable Sites Initiative provide “sustainability” guidelines that encourage ecosystem service-based landscapes designed to enable performance monitoring. By experimenting with GSI, planning boards may begin to understand which specific GSI systems (or best management practices) are doing what. In this way, institutions can make less risky decisions when planning for larger scale projects, as well as practice diverse, smaller scale strategies, and cultivate a culture of resilient planning and design in general. At UMass Amherst, the university may benefit from first piloting monitorable, small-scale green infrastructure installations in order to merit stakeholder investment and make more informed investments in green infrastructure across campus.

As an EPA designated Municipal Separate Sewer System (MS4), UMass Amherst Campus is under pressure to incorporate green infrastructure in its stormwater management plan, and on top of that, the University has made a renewed commitment to sustainability. As an educational center with a new vision of sustainability, UMass Amherst has the opportunity to integrate GSI campus wide, while improving student life and public spaces. GSI on campus could turn a municipal cost into an opportunity to improve water quality downstream, to provide shade, to reduce the urban heat island effect, to improve campus aesthetics, to provide habitat for wildlife, to enrich biodiversity, and to shape attractive, comfortable, psychologically-pleasing spaces for student to enjoy. This master’s project proposes that the University of Massachusetts Amherst pilot a ecosystem-service based green stormwater infrastructure demonstration site and educational platform following Sustainable Sites Initiative guidelines to explore monitoring methods that could provide useful data for future campus GSI planning initiatives.

The landscape in front of the Fine Arts Center presents an opportunity for GSI intervention. It is adjacent to the new Design Building and a new addition to the Isenberg School of Management. Under the central walkway, an enormous amount of polluted stormwater runoff rushes through a 36” pipe underground, which discharges into the campus pond. This location has the opportunity to showcase various types of testable GSI and provide an outdoor education platform that both students and visitors could interact with. This GSI education platform could serve as a pilot project that simultaneously improves campus sustainability and tests ways of monitoring water quality. Designed experiments may serve to provide both collaborate educational opportunities on campus and as grounds for their application campus wide.

## PROJECT OVERVIEW

This master’s project proposes an educational green stormwater infrastructure (GSI) demonstration site, planned and designed using Sustainable SITES Initiative in front of UMass Amherst’s Fine Arts Center that could provide a precedent for future GSI projects. A 36” pipe carries hundreds of thousands of gallons of stormwater runoff underneath the site. The pipe carries polluted stormwater from a network of storm drains and catch basins east of North Pleasant Street down to the campus pond. The pipe passes under the main walkway between North Pleasant Street and Haigis Mall before dipping under the FAC and emptying into the campus pond. This project proposes that the pipe will be momentarily daylighted and sent through a series of best-management-practices designed to monitor ecosystem services, with safe-to-fail overflow outlets. The monitorable GSI system will have educational platforms where visitors and students can read and experientially learn about stormwater management on campus. The GSI demonstration site has the potential to offer interdisciplinary research across

fields and could be used by landscape architects, regional planners, horticulturists, soil scientists, campus planners, and engineers. The location of this massive exposure of stormwater is appropriate in that it is in a highly trafficked area in between the Studio Arts Building, the proposed Design Building, and the Fine Arts Center. This project aims to meet some of the campus’s MS4 objectives, and proposes new experimental and educational methods for the sustainable, ecosystem-service based planning and design of green infrastructure on campus.

## PROJECT GOALS:

- 1) Improved views and circulation in relation to FAC, DB, and ISOM addition
- 2) Artful display of sustainable green stormwater infrastructure
- 3) Explore ways of monitoring ecosystem services
- 4) Outdoor classrooms for interdisciplinary collaboration
- 5) The opportunity to help UMass meet some of its MS4 objectives

## RESEARCH QUESTIONS:

- What are the campus’s needs in relation to stormwater management?
- What kinds of ecosystem services are GSI systems capable of providing?
- How can the GSI be designed to encourage resilient campus-wide planning, design, and transdisciplinary collaboration?
- How can the Sustainable Sites Initiative v2 guidelines push sustainable landscape architecture forward?



CHAPTER 2

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LITERATURE REVIEW  
& CASE STUDIES



# LITERATURE REVIEW

For the first time in history, human activity on planet Earth is behaving as geologic force; the planet has entered into what scientists are referring to the Anthropocene. According to the UN Millenium Ecosystem Assessment report (2005) “over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history” in order to meet human needs. Of the ecosystem services (or total services supplied by ecosystem processes that support human life) examined by the Millenium Ecosystem Assessment, 60% are being used unsustainably. Scientists have only begun to evaluate the value of these services, which could be grossly underestimated (Costanza, 1997). At the core of the Millennium Ecosystem Assessment is this: “a stark warning. Human activity is putting such strain on the natural functions of Earth that the ability of the planet’s ecosystems to sustain future generations can no longer be taken for granted” (Millennium Ecosystem Assessment, 2005, p. 7 in: Windhager, 2010, p. 108). Lack of sustainable and resilient planning and thinking has lead to gross environmental degradation of global natural resources and subsequent loss of ecosystem services.

Water is one of the most important natural resources intimately tied to ecosystem service processes. Water, the universal solvent upon which all life depends, is a vulnerable resource that will both strongly influence and be strongly influenced by development. As stated by Jack Ahern, “because water is the essential and primary integrating resource, planning for water affects – and is affected by – most other sectors of physical urban planning, including land use, transportation, infrastructure, open space, waste processing and energy generation and transmission” (2010, p. 137). As stated by Novotny (2010) “All life depends on water: government regulations address water resources; water transports materials and nutrients; cities are increasingly facing challenges to manage larger amounts and frequencies of extreme rainfall” (Novotny et al. 2010).

Climate change will increase precipitation events over shorter periods of time in the Northeast (Houghton IPCC, 1995), increasing the burden on conventional urban hydrologic systems, many of which are already at capacity (Ashley et al., 2005 in Chen et al., 2014). The potential to create a resilient built environment may depend, in part, on the re-evaluation of conventional planning and design approaches and the intentional integration of ecosystem services into urban planning and design of stormwater infrastructure.

The University of Massachusetts Amherst is beginning to take sustainability and climate change more seriously. In 2007, the American College and University President’s Climate Commitment was signed by UMass President Jack Wilson, who recognized the need to make major changes in policy and planning for the whole campus. The ACUPCC aims to re-establish stable climate conditions. By signing the document, Wilson committed UMass to addressing global climate change through initiating a focus on relevant research and through making educational efforts to teach students how to preserve the stability of the climate (Chen et al., 2014). Since 2007, UMass has made other efforts to promote sustainability through education, involvement, and awareness (Chen et al., 2014).

## CONVENTIONAL STORMWATER MANAGEMENT

Stormwater runoff managed through conventional grey stormwater infrastructure management drastically alters the “natural” hydrologic. Stormwater runoff occurs when stormwater cannot infiltrate into the ground due to the presence of impervious surfaces (i.e. roofs, paved parking lots and streets). Pollutants (including car oil, grease and gas, heavy metals, suspended solids, trash and debris) on the catchment surfaces are concentrated into stormwater run-off,

which are then channeled into a grey infrastructure system comprised of catch basin and conveyance pipes. Polluted stormwater runoff is then directly deposited into water bodies or combined with sanitary sewage and then sent to a water treatment facility (which can also overflow during wet weather conditions, resulting in combined sewer overflows). In conventional urban development, wetlands, which are important sources for mitigating urban stormwater runoff, are frequently paved over. Natural watercourses, including the Tan Brook on UMass Amherst’s campus, are often buried, culverted and re-directed from their pathways, resulting in flood prone tendencies along their original routes. Reduced infiltration causes reduced evapotranspiration, resulting in increased temperatures in densely impervious areas (Stone, 2012). The urban landscape also has reduced storage capacity due to impervious cover and soil compaction. Loss of natural amelioration of stormwater is characterized by increases in run-off velocity, run-off volumes, and discharge rates and floods (Parkinson and Mark, 2005).

Stormwater run-off has negative affects on the ecological systems of receiving water bodies. Stormwater run-off from impervious surfaces creates peak volume discharges that both pollutes and erodes the banks and channels of receiving water bodies and streams. Erosion causes an excess of sediment load in streams, which can affect aquatic ecology. If a stream experiences an overload of sediment, suspended solids can cause fish gills to become clogged. Suspended solids can also fill voids some species depend on in order to lay their eggs, negatively affecting spawning (NRCS, “Effects of Sediment”). Impervious surfaces, which soak up heat, also increase water temperatures, affecting dissolved oxygen content, therefore compromising the ability of a waterbody to support ecologically significant species of fish.

Tan Brook, a primarily culverted stream, is a major component of UMass Amherst's stormwater management system. The stream originates at a pond east of Amherst. From the pond, Tan Brook moves past a few public schools, through downtown where it is subject to substantial polluted stormwater runoff from a large parking lot. Then, it is directed underneath campus, where it is combined with another pipe carrying campus stormwater runoff, before it is deposited into the Campus Pond. Catch basins east of the pond also directly dump into the pond. A stormceptor east of campus collects runoff from catch basins upslope, where it separates suspended solids before depositing it into the campus pond. The remaining catch basins all directly deposit into a stormceptor that separates suspended solids. There are several catch basins on campus. Stormwater collected outside of the areas already discussed gathers and collects into a few large pipes which ultimately discharge into the Mill River. At the south side of the athletic fields, there is an overflow outlet. This conventional grey infrastructure system has exacerbated the hydrologic integrity of the Tan Brook, causing erosion, compromised water quality, destructive peak discharge volumes, and most prominently the accumulation of sediment (Chen et al., 2014).

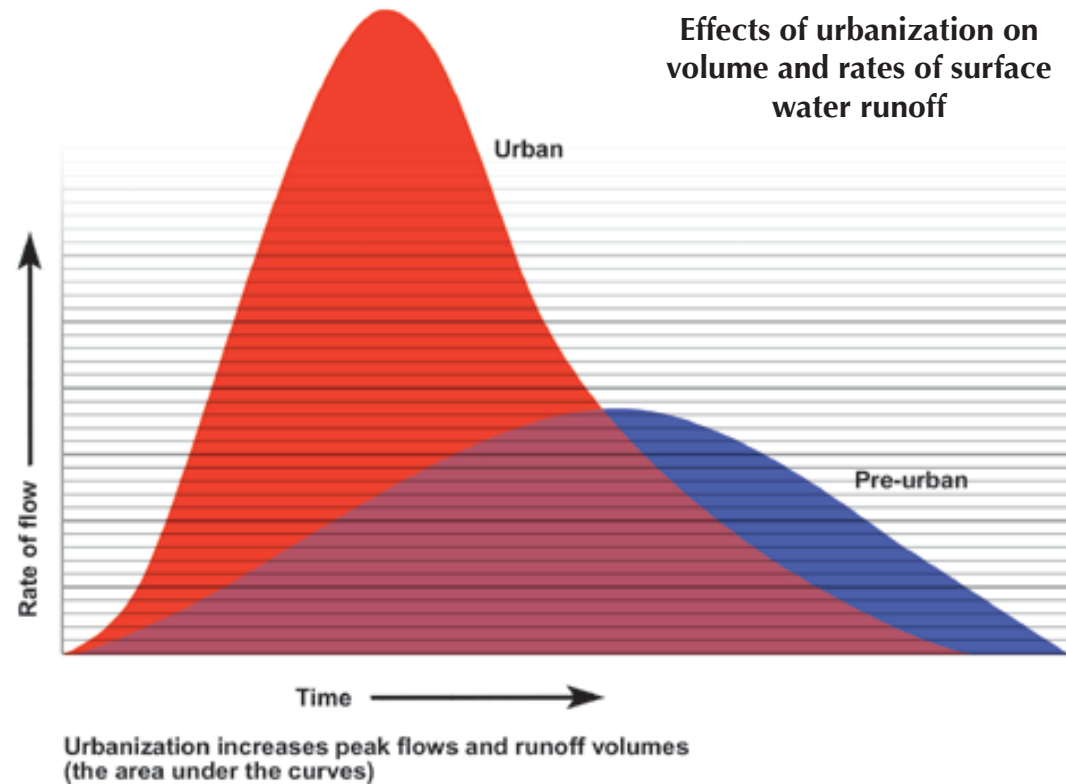
Conventional stormwater management has created enormous problems both globally and locally. Because these issues have the potential to affect reduce baseflow, pollute groundwater, streams and waterbodies, the management of urban stormwater extends far beyond the extent of the urban center itself: the number one source of pollution to American water bodies is polluted stormwater runoff. The ubiquitous presence of impervious surface in urban environments clearly creates a myriad of environmental problems resulting from excessive stormwater run-off. For all of these reasons, slowing and infiltrating stormwater needs to be a priority in the design for resilience and sustainability.

## 1.2 Regulatory Pressure

Recognizing the severity of these issues, the Environmental Protection Agency (EPA) has taken measures to reduce the harmful implications of conventional grey infrastructure systems. In 1972, the National Pollutant Discharge Elimination System (NPDES) was established through the Clean Water Act. Up until then, "only point-source pollution (or direct, un-treated pollutant dumping into water bodies) had been regulated, and stormwater runoff had been considered non-point source" (Carlson, et al., p. 6, 2014). However, due to the increasingly threatened impaired waterbodies, the EPA recognized

"that a concentration of non-point source pollutant-dumping [such as a college campus or a small city] behaves like point-source pollution," and therefore, "the NPDES program redefined point-source criteria, expanding the regulation to includes Municipal Separate Storm Sewer Systems (MS4s)" (Carlson et al, 2014, p.6). MS4s have since been required to obtain a NPDES permit to discharge into water bodies.

The EPA has is pushing municipalities to begin incorporating green infrastructure into stormwater management systems. While there are many varying definitions of green infrastructure, it is widely recognized as a system into which natural ecosystem



<https://ec.gc.ca/eau-water/default.asp?lang=En&n=72FDC156-1>



processes are integrated. Viewed by Jack Ahern as the “infrastructure of sustainability” (2014), Ahern defines green infrastructure as “spatially and functionally integrated systems and networks of protected landscapes supported with protected, artificial, and hybrid infrastructures of built landscapes that provide multiple, complementary ecosystem and landscape functions to the public, in support of sustainability” (Ahern 2007). The integration of green infrastructure is central to the EPA’s vision for municipal, sustainable stormwater management.

Under the NPDES Stormwater Program Phase II, the University of Massachusetts was classified as an MS4, subjugating it to a set of sustainable stormwater management measures. In preparation for the EPA’s increasingly stricter stormwater regulations, UMass Amherst has made some adjustments the existing stormwater management system over the past decade. New green stormwater infrastructure (GSI) best-management-practices (BMPs) have been installed in a few spots around campus. Many of the new buildings have BMPs installed upon construction. UMass has agreed to begin to address the stormwater system at large using BMPS (such as rain gardens and permeable pavers) (UMass Climate Action Plan, 2010). The largest installation of BMPs on campus is in the Southwest Corridor, where permeable pavers and stepped bioretention cells infiltrate large quantities of stormwater, allowing for the removing of 25 catch basins. However, there are currently no other large-scale installations on campus.

The new NPDES requirements, expected to be released in 2016, will impose much stricter measures on UMass’s stormwater management policies. For example, UMass will need to be able to abide by six minimum control measures:

- I. Public education and outreach
- II. Public involvement and participation
- III. Illicit discharge detection and elimination

- IV. Construction site runoff control
- V. Post-construction stormwater management in new development and redevelopment
- VI. Pollution prevention and good housekeeping for municipal operations and maintenance

UMass will also have to reassess if current planning policies are geared towards green infrastructure, report on reduction of impervious surfaces over time, inventory UMass property that could be retrofitted with green infrastructure in order to slow peak stormwater discharges, and report on the results of the integration of best-management-practices (BMPs). The first minimum control measure, Public Education and Outreach, is especially of interest for this project; because the municipality in this case is a public university, campus has a unique opportunity and obligation to make education an important part of GSI.

### 1.3 Modernist Master Planning & Conventional Stormwater Management

Urbanization, guided by modern planning and design principles, has resulted in the development municipalities that lack resilience in the face of the evolving social, environmental and economic forces prevalent today. At the core of the modernist mentality are the concepts of “optimization” and “efficiency”. Optimization is essentially the idea that planning can be based on the “optimal” state (of a city’s processes), and that cities develop in a linear progression. The optimization model supposes monofunctionality, the concept that each component has its place and serves one purpose. However, as these urban issues compound, it is becoming clear that there may be no optimal state; the optimization, as a goal, is not fit to be responsible and flexible to the emerging needs and changes in dynamics of rapid urbanization. Optimization “is often configured and reconfigured by extreme events, rather than by average, day-to-day events and incremental change”

(Ahern, 2010, p. 145). Linked to optimization is efficiency, because by optimizing, there is no need for redundant infrastructure, and it is eliminated (Ahern, 2010). Optimization creates systems that can handle the “perturbations” they were designed to manage, but in the face of unanticipated events, they are fragile and limited (Carlson and Doyle, 1998). The concepts of optimization and efficiency are clearly demonstrated in conventional stormwater management and transportation systems.

Conventional stormwater management is essentially based on the concepts of optimization and efficiency. As development expands the stormwater systems currently in place cannot manage the increased run-off due to the expansion of impermeable surface cover. In conventional systems stormwater management is efficiently optimized; stormwater is removed off site as quickly as possible. Storm drains are concentrated into massive pipes that channel polluted water at high speeds into even bigger pipes, discharge directly into water bodies, or get combined with sewage and sent to large water treatment facilities. As previously discussed, peak discharge volumes are detrimental to our waters. Clearly, the modern, top-down approach, based on the concepts of optimization and efficiency (and one-size-fits all mentality), is not working.

## A NEW VISION OF SUSTAINABLE PLANNING & DESIGN

A re-evaluation of the top-down planning and design strategies associated with the modernist era and a call for more “sustainable” practices is taking place (UN Habitat, 2009). Sustainable planning and design practices offers an opportunity to begin experimenting with alternative forms of designing and planning for infrastructure systems that intentionally integrate ecosystem services and counter some of the modernist principles. In fact, perhaps the opposite

of many of modernism's principles offer many of the solutions to the problems we face today: instead of optimization and efficiency we need modularization and redundancy; instead of monofunctionality, we need multi-functionality; instead of large scale master planning, we need small-scale, adaptive and experimental designs that can be monitored; instead of static achievement oriented design, perhaps ecosystem service based design with performance monitoring standards offer a new vision of sustainability.

## 2.2 Re-envisioning Sustainability

The most broadly used definition of sustainability is the ability to meet the needs of the present “without compromising the ability of future generations to meet their own needs” (Bruntlant, 1987). Some planners and designers are beginning to question the meaning of sustainability. Until recently, sustainability was thought of attaining a stable state that could persist over time; in other words, it was seemingly understood that cities could “achieve sustainability”. However, because change is fundamental to any system, to seek stability, but resist change, presents a paradox (J, Ahern, LA/RP 582 lecture, January 22, 2015); a system that is constantly evolving and adapting will never reach a static state. The mainstream understanding of sustainability is limited.

Landscape urbanists are developing a new vision of sustainability that incorporates resilience theory (Ahern, 2010). Landscape urbanism theory re-envision cities as organisms with their own variables and dynamic patterns and processes, subject to varying levels of disturbance that can not always be planned for. Walker and Salt (2012) describe resilience as “the capacity of a system to absorb disturbance and reorganize so as to retain essentially the same function, structure, and feedbacks – to have the same identity” (p. 3). Therefore resilience “determines how vulnerable the system is to

unexpected change and surprises” (Alberti, 2008, p. 6; Gunderson and Holling, 2002), (i.e. how vulnerable a city and its subsystems are to natural disasters, etc.). A municipality may be planned and designed resiliently, incorporating infrastructure that allows it to be able to recover from a disturbance and bounce back to its fundamentally original state. According to Jack Ahern, “to achieve sustainability and resilience in cities, urban infrastructure must be reconceived and understood as a means to improve and contribute to sustainability” (Ahern, 2010, p. 137). Sustainable stormwater planning and design should therefore incorporate resilient planning that emphasizes learning from experience, integrating adaptive/responsive methods (i.e. monitoring), and recovering from disturbances.

## 2.3 Five Principles for Sustainable Planning and Design

Jack Ahern presents five Resilience Planning Strategies in his Transdisciplinary Method for Spatial Planning of Resilient-Sustainable Cities (2010). The principles are multifunctionality, redundancy and modularization, (bio)diversity, multi-scale networks, and adaptive capacity (p. 145). These principles could offer municipalities, including UMass, basic guidelines or goals to use for the planning and design of stormwater infrastructure.

Multi-functionality is the idea that because space is limited, “multiple functions can be ‘stacked’ in one location” (p. 146). For example, a bioretention cell can be designed to not only infiltrate stormwater, thereby reducing municipal stormwater management costs, but it can also recharge ground water, enhance aesthetics, provide habitat, provide food for animals and people, reduce the effects of the urban heat island through transpiration, provide shade, increase real estate value, and possibly reduce crime rates. All of these functions are stacked into one system, therefore making the system multi-functional.

Modularization refers to the use of many separate sub-systems (modules) in place of one conglomerate, centralized system. As opposed to the modernist concept of efficiency, in which all efforts are concentrated in one place, modularization and redundancy spread the work to many different smaller systems. In the context of stormwater management, modularization could mean that instead of relying on a network of storm drains that combines stormwater and sanitary sewer lines into one massive pipe and off to a waste water treatment plant, a municipality might have several smaller BMPs integrated into its urban fabric that each treat stormwater closer to or at its source.

Redundant systems may either serve the same function or behave as back-ups. In the case of failure, risk is spread, reducing vulnerability of the whole system at large. Redundant, modular subsystems take the pressure off the mega pipe and treatment facility, so that if something goes wrong with the overall system, sub-systems can still continue to function on their own. In the case of stormwater management, during a hurricane or irregularly large storm, redundant GSI systems will each respond to the disturbance in different ways, some more successfully than others, whereas a municipality relying entirely on one interconnected grey infrastructure system has one chance to get it right. If the pipe network fails, the municipality may experience more severe flooding.

Another principle of Ahern's Resilience Strategies is diversity. Diversity entails biodiversity or species richness, functional diversity, and response diversity. Biodiversity in a system increases the odds of an ecosystem to withstand a disturbance, because different species have various tolerance ranges: the more species, the more tolerance a system has. Functional diversity refers to all the different components' functions of an integrated system. Response diversity refers to the various responses that the system's components have to different

disturbances and stresses (Ahern, 2010). A diverse green infrastructure system can represent each of these kinds of diversity: a network of bioretention can provide biodiversity through with a mixture of plant communities; functional diversity is demonstrated through a set of GSI systems that have different specialized functions such as infiltration, phytoremediation, and evapotranspiration; finally, response diversity can be displayed through various designed GSI systems that respond differently to various disturbances (such as flooding, pollution, or water shortage). Multiscale networks and connectivity refer to the

degree of connectedness of functions across scales. For example, a GSI system can be connected to a larger natural system, such as an open space network, greenway, and regional hydrologic systems.

Adaptive capacity describes a new approach to planning in which experimentation is allowed; because precedents are limited, monitoring pilot projects and plans and designs will need to be adopted “as you go”. Encouraging small-scale experimentation with sustainable/resilient infrastructure, while admitting risk of failure allows new ideas to be explored, for “if planners and

designers only think defensively about avoiding or minimizing impacts related to infrastructure (re) development, the ‘target is lowered’, actions become conservative, and the possibility to innovate is greatly diminished” (Ahern, 2010, p. 137). A GSI system can be designed to incorporate monitoring methods so that polluted stormwater quality and quantity is being tested both before and after it enters the system. Results of the experimentation can be incorporated into future projects, thereby allowing an evolving process of refining GSI systems that are appropriate for myriad contexts.

Multifunctionality, redundancy and modularization, (bio)diversity, multi-scale networks, and adaptive capacity are all important concepts that could guide sustainable management of stormwater on campus. These five resilience principles provide the basis for ecosystem-service based design guidelines which should be integrated into a planning and design approach for the sustainable stormwater management on campus.

## 2.4 Integrating Ecosystem Services

Ecosystem services emerged as a mainstream concept in nineties, and was popularized by the development of the Millenium Ecosystem Assessment in the early 2000s. Robert Costanza, a prominent theorist of ecosystem services and a world-leading ecological economist, states that ecosystem services “refer variously to the habitat, biological or system properties or processes of ecosystems. Ecosystem services such as goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions” (1997, p. 253). Ecosystem services are “benefits that the environment provides to humans at no cost, benefits we would have to provide for ourselves if our surroundings ceased to provide them (Costanza et al. 1997). Much like a natural ecosystem, “ecosystem services consist of flows of materials, energy, and information from natural



*A GSI drainage basin at the Philadelphia Zoo exemplifies Ahern’s “multifunctionality” principle. The design stacks the functions of managing stormwater, enhancing beauty, and providing a place for visitors to interact with nature.*

[http://www.phillywatersheds.org/sites/default/files2/Zoo\\_485\\_Sharp.jpg](http://www.phillywatersheds.org/sites/default/files2/Zoo_485_Sharp.jpg)



capital stocks which combine with manufactured and human capital services to produce human welfare” (Costanza, 1997, p. 254).

In the context of the urban environment, cities may be reconceived as urban ecosystems manipulated by human intervention and thus inseparable from “nature”, which expands the concept of abiotic/biotic ecosystem services to include cultural ecosystem services. Landscape architects Ahern (2010), Dreisseitl and Grau (2009) argue “sustainable landscapes must do more than provide biophysical functions and services, they can must perform socially and culturally, intersecting with social routines and spatial practices” (Ahern, 2010, p. 14). Therefore when ecosystem services are discussed in the urban context, human health, and cultural benefits are also included in what is perceived of as a “ecosystem service”.

The UN Millennium Ecosystem Assessment (2005) classifies ecosystem services as provisioning, regulatory, supporting, and cultural services. Regulating services regulate climate, water, natural hazards, disease, water purification and waste treatment. Provisioning services provide products from natural resources such as freshwater, food, fuel, and fiber. Supporting services enable nutrient cycling and the primary production of all other services, but are not directly accessible to humans. Cultural services provide recreational, educational, psychological, cultural, and spiritual benefits (UN Millenium Assessment, 2005).

Ecosystem service expert Gretchen Daily believes that ecosystem services “maintain biodiversity and the production of ecosystem goods; [they] are the actual life-support functions, such as cleansing, recycling, and renewal, and they confer many intangible aesthetic and cultural benefits as well” (1997, p. 3). Expanding the definition of ecosystem services to include cultural and aesthetic benefits, “is closely aligned with a broad, multidimensional, and balanced

## ECOSYSTEM SERVICES

Ecosystem services are goods and services of direct or indirect benefit to humans that are produced by ecosystem processes that involve the interactions of living elements, such as vegetation and soil organisms, and non-living elements such as bedrock, water, and air.

The *Millennium Ecosystem Assessment* 2005 report separated ecosystem services into four categories: Supporting (services that are necessary for the production of all other ecosystem services), Provisioning (products, such as food and water, obtained from ecosystems), Regulating (benefits obtained from the regulation of ecosystem processes such as carbon sequestration), and Cultural (nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences).

Researchers have developed various lists of these benefits and services. The Sustainable Sites Initiative has consolidated the research into the following list of ecosystem services that a sustainable site can protect or regenerate through sustainable land development and management practices.

### Global climate regulation

- Maintaining balance of atmospheric gases at historic levels
- Maintaining healthy air quality
- Sequestering carbon

### Local climate regulation

- Regulating local temperature, precipitation, and humidity through shading, evapotranspiration, and windbreaks

### Air and water cleansing

- Removing and reducing pollutants in air and water

### Water supply retention

- Storing and conserving water within watersheds and aquifers

### Erosion and sediment control

- Retaining soil within an ecosystem
- Preventing damage from erosion and siltation

### Hazard mitigation

- Reducing vulnerability to damage from flooding, storm surge, wildfire, and drought

### Pollination

- Providing for the reproduction of crops and other plants

### Habitat functions

- Providing refuge and reproduction habitat to plants and animals, contributing to the conservation of biological and genetic diversity and evolutionary processes

### Waste decomposition and treatment

- Breaking down waste
- Cycling nutrients

### Human health and well-being

- Enhancing physical, mental, and social well-being as a result of interaction with nature

### Food and renewable non-food products

- Producing food, fuel, energy, medicine, or other products for human use

### Cultural benefits

- Enhancing cultural, educational, aesthetic, and spiritual experiences as a result of interaction with nature

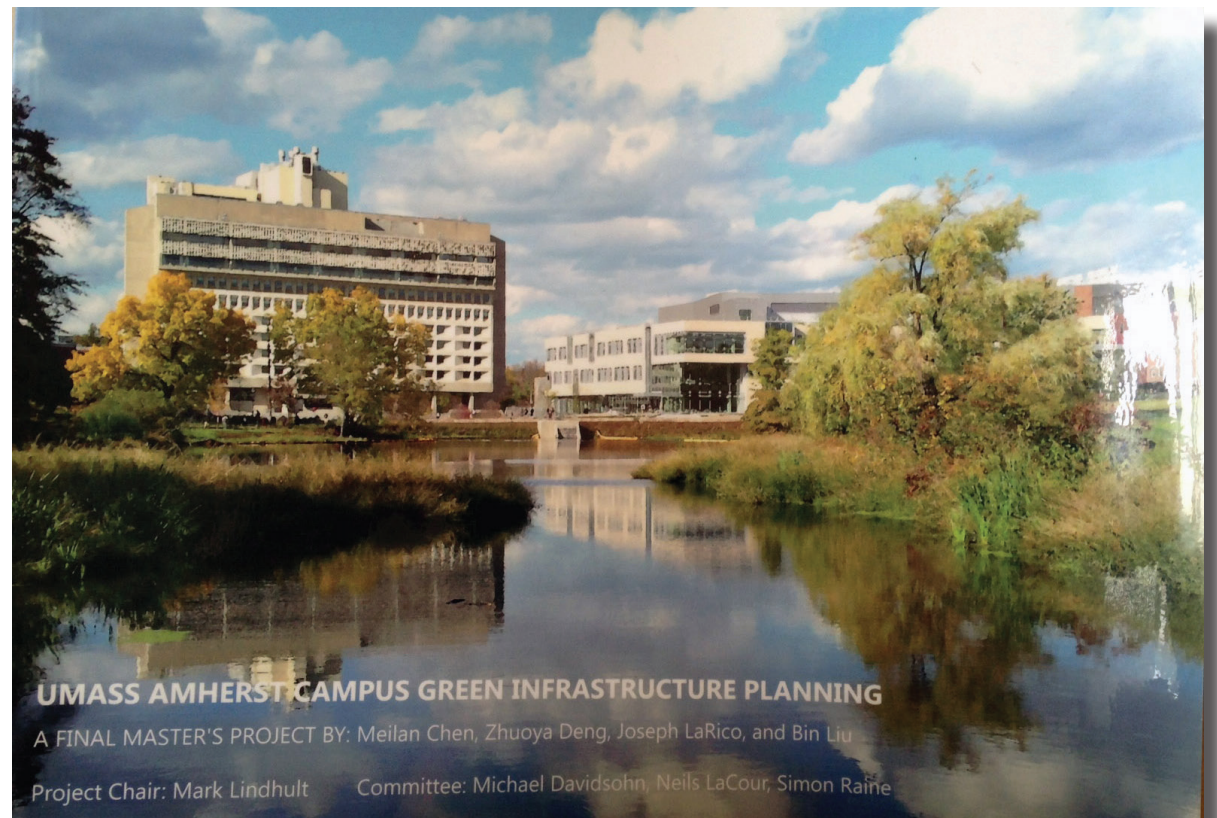
*The Sustainable SITES Initiative Defines Ecosystem Services above; SITES v2, 2014, p. x*

conception of sustainability in general” (Ahern, 2010, p. 140).

In “Planning and Design for Sustainable and Resilient Cities”, Jack Ahern proposes that municipalities adopt a planning method driven by ecosystem service-based design guidelines, asserting that ecosystem services should be assessed and evaluated. In this way they “therefore can serve well as assessment metrics linking urban form (pattern) with urban process (ecosystem services)” (Ahern, 2010, p. 144). By identifying these services, benefits can be scientifically measured and evaluated in the transdisciplinary process. Then, “once articulated, quantified and mapped, ecosystem services logically become the goals and benchmarks of progressive urban sustainability planning” (Ahern, 2010, p. 144). Basing planning and design guidelines on ecosystem services may provide a way “to make many environmental and economic, as well as some social objectives explicit and measureable and thereby make greater and coordinated progress toward a more sustainable culture” (Windhager et al., 2010, p. 105). Perhaps, “what has been missing is a method to consolidate environmental design efforts into larger ecological, economic, and social benefits both at the site level and beyond. Ecosystem services provide a conceptual model to describe these benefits and link them directly to the economic framework that governs development practices” (Windhager, 2010, 108). In order to incorporate these resilient concepts, Campus Planning could explore a new, more experimental, ecosystem-service based approach to managing stormwater. Ecosystem service-based goals with performance monitoring standards could provide the key to planning and design of sustainable stormwater management on campus. After all, water, a critical resource for life, is arguably the most important resource around which design decisions should be made.

Campus Planning would benefit from integrating Ahern’s five principles for sustainable planning and design into a campus-wide approach for managing stormwater. Instead of monofunctional pipe networks or gated-off stormwater discharge areas, campus could instead focus on designing multi-functional GSI that also provides habitat, shade, and comfortable spaces for people. Instead of a collection of massive pipes channeling stormwater into waterbodies, campus could integrate multiple, redundant BMPs close to its source, avoiding the need for large, expensive grey infrastructure networks lower in the watershed. The campus could experiment with diverse BMPs to experiment with system efficacy. The campus could also expand its plant pallet to

intentionally incorporate native species and provide habitat. When all of these BMPs are linked together, a multi-scale network emerges that could potentially connect to green streets in downtown Amherst with riparian corridors in North Amherst. Finally, and most importantly for this project, Campus Planning could adopt adaptive, interdisciplinary designs that prioritize ecosystem services and test their efficacy in order to create a more resilient campus. Guided by multifunctionality, redundancy and modularization, (bio)diversity, multi-scale networks, and adaptive capacity, UMass Amherst could adopt ecosystem-service based design guidelines for managing stormwater on campus that would maximize the ecosystem services that GSI can provide.



2015 MLA Master's Project by Meilan Chen, Zhouya Deng, Joseph LaRico, Bin Liu

## GREEN STORMWATER INFRASTRUCTURE & ECOSYSTEM SERVICES

Green Stormwater Infrastructure (GSI) provides a sweet of ecosystem services that fall into the UNEP's regulating, supporting, and cultural ecosystem service categories. There are many different kinds of GSI systems and in general, their main purpose is to slow and infiltrate stormwater thereby reducing peak discharge volumes and velocity. GSI can also be described as a type of Low Impact Development or LID. LID is the practice of using natural systems to control stormwater runoff. According to the National Resource Defense Council, "LID strategies integrate green space, native landscaping, natural hydrologic functions, and various other techniques to generate less runoff from developed land" (NRDC, 2011). There are five main categories of GSI: bioretention planters (bioswales, constructed wetlands, stormwater planters, rain gardens), permeable paving (porous asphalt, pervious concrete, permeable interlocking pavers), tree pits (tree box filters, open/closed tree trenches), vegetated swales, and vegetated roofs (USEPA, 2000). Some are better than others in their ability to improve water quality, lower water temperature, reduce the urban heat island effect, provide biodiversity and habitat, save money on operations and maintenance costs, and improve aesthetics.

### 3.1 Water quality and pollutant removal

One of the most important ecosystem services that GSI systems provide is the ability to cleanse pollutants from stormwater runoff. The most common pollutants present in urban runoff are sediment (as Total Suspended Solids), phosphorus, nitrogen, hydrocarbons, and bacteria.

Bioretention cells and swales have shown they

effectively treat of pollutants as well as provide cultural ecosystem services. For example, a study "a bioretention cell in Raleigh, NC significantly reduced the concentrations of fecal coliform and E. coli in stormwater." (Hunt et al., 2008 in LPS Fast Fact Library). In another nine-year-study, it was determined that "a bioinfiltration rain garden clearly removed the pollutant orthophosphate from stormwater[...] Pollutant removal remained steady over the nine years of study" (Komlos et al., 2012 in LPS Fast Fact Library). Again, another experiment in Seattle which utilized "event-based sampling on a street-side bioretention facility [...] found that over a 2.5-year period, 48-74% of the incoming runoff was infiltrated or evaporated. Outlet pollutant concentrations were significantly lower than those at the inlet for total suspended solids (TSS), total nitrogen, total phosphorus, copper, zinc, and lead. Motor oil was removed most effectively, with 92-96% removal efficiency" (Chapman and Horner, 2010 in LPS Fast Fact Library). Bioretention cells and swales are often preferred by landscape designers as they can be discrete and also enhance beauty in the landscape.

Constructed wetlands, another type of GSI, are extremely effective in removing pollutants, yet they are in general, less aesthetically appealing and less usable by people. Constructed wetlands are often designed in conjunction with specific plant selections to target pollutant removal. Often, the more vegetation present, the more pollutant removal occurs. For example, "a 2014 study found that tanks with floating wetlands populated with *Iris pseudacorus* removed 54 times more nitrogen and 10 times more phosphorus from the water than a control tank with no vegetation" (Keizer et al., 2014 in LPS Fast Fact Library). Another experiment in China showed tested 27 simulated wetlands which showed "that constructed wetlands planted with macrophytes (large aquatic plants) remove more nutrients than unplanted wetland systems." The scientists discovered that "nutrient uptake by plants accounted for 14-

52% of Total Nitrogen removal and 11-34% of Total Phosphorus removal" (Wu et al., 2011 in LPS Fast Fact Library). Clearly, sheer biomass plays an important role in a constructed wetlands efficacy.

Climate and season does seem to play a part in the efficacy of bioretention cells and constructed wetlands in removing pollutants. Studies show that many of the LID systems perform best in the summer, but that they do show decline in efficacy over the winter months. For example, in one study, "Low-impact stormwater management systems in the cold climate of New Hampshire had less seasonal decline in performance than conventional best-management-practices [retention ponds, swales]. LID systems included subsurface infiltration, bioretention, gravel wetlands, a porous asphalt system, a street tree, and seven proprietary systems. Frozen filter media did not reduce performance" (Roseen et al., 2009 in LPS Fast Fact Library). Another study showed "that a constructed stormwater wetland [was] effective in removing phosphorus, nitrogen, total suspended solids, copper, and E. coli in stormwater runoff." (Wadzuk et al., 2010 in LPS Fast Fact Library). The wetland hosted 20 plant species, and treated a stormwater from an area 45 times its size. The study showed that "phosphorus, nitrogen, and suspended solids were removed nearly year-round, with removal of total suspended solids highest during the summer. Performance of the wetland was consistent over two year-long periods four years apart, though no maintenance was performed on the wetland" (Wadzuk et al., 2010 in LPS Fast Fact Library). Pollutant removal is an extremely important ecosystem service that GSI provides.

Finally, according to a recent study, daylighting of streams has the capacity to increase nitrogen retention on the watershed-scale. The study shows that "nitrate travels on average 18 times farther downstream in buried streams than in open ones before being removed from the water column" (Beaulieu et al.,



2015 in LPS Fast Fact Library). In summary, various GSI BMPs have the ability to provide the ecosystem service of removing detrimental pollutants from stormwater runoff.

### **3.2 Reduced Urban Heat Island Effect & improved air quality**

GSI also provides the ecosystem service of reducing the urban heat island effect. The urban heat island effect is the phenomena of urban centers experiencing higher temperatures than more vegetated, rural areas due to presence of heat-trapping impervious surfaces. Because GSI creates habitat for trees, shrubs, and vegetation to thrive, GSI provides the ecosystem

service of evapotranspiration, which helps reduce the urban heat island effect. For example, in one study trees in bioswales showed a reduced rate of runoff and discharge as they evapotranspired water into the atmosphere. In the study, “transpiration from trees in bioswales at The Morton Arboretum parking lot in Illinois accounted for 46-72% of the lot’s total water output” (Scharenbroch et al., 2015 in LPS Fast Fact Library).

Not only do trees and some vegetation help with reduce the urban heat island effect, but many in the process also remove pollutants from the air as they transpire. For example, “computer modeling estimates that urban trees in the contiguous U.S.

remove 711,000 metric tons of carbon, monoxide, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide each year, a service with an annual value of \$3.8 billion.” This study shows how important it is to put a price on ecosystem services, as doing so will help policy makers take the studies more seriously. The study was performed for 55 U.S. cities and for the entire nation. Ultimately, the study showed that “typical air pollutant removal per city was hundreds to thousands of metric tons per year” (Nowak et al., 2006 in LPS Fast Fact Library).

### **3.3 Peak discharge volume & temperature control**

As previously discussed, stable baseflow and stream



<http://www.sustainablesites.org/phipps-center-sustainable-landscapes>

temperature is an important part of the health of streams, and GSI provides the ecosystem service of reducing water temperature and slowing stormwater runoff. In cold water fishers, ecologically significant fish are threatened when the water temperature drops below 23 degrees, as at that point, the dissolved oxygen content gets too low. However, GSI can “reduce the temperature of thermally charged stormwater runoff from an asphalt surface. In a Blacksburg, Virginia study, the average thermal pollution reduction was nearly 37 MJ/mJ, although the facility was unable to consistently reduce the temperature below the threshold for natural trout waters in Virginia” (Long et al., 2014 in LPS Fast Fact Library). Because GSI intercepts stormwater rushing from pipes and slows it down, receiving waterbodies experience reduced erosion and reduced sediment. Volume and temperature control are important ecosystem services that will become even more important for aquatic life as the climate warms and experiences more acute storms.

### 3.4 Increased biodiversity

GSI can also provide habitat for pollinators, birds, and other wildlife. In one study in Queensland, Australia increasing the quantity of mature, native trees proved to be an “effective way to increase bird diversity”. The study showed that “streets that retained mature trees had similar species composition to urban parks but fewer total birds” (Barth et al., 2015 in LPS Fast Fact Library). One study also showed that in a residential development, bioretention swales demonstrated more biodiversity than any other kind of landscaping. The study “in Melbourne, Australia compared invertebrate species richness and diversity in streetside bioretention swales, garden beds, and lawn-type planting strips. Bioretention swales contained the greatest species richness and diversity, followed by garden beds and lawn-type green spaces” (Kazemi et al., 2009 in LPS Fast Fact Library). GSI has the potential to increase biodiversity in urban areas.

GSI has the potential to provide a suite of ecosystem services that should provide the basis for sustainable planning and design decisions. Specific GSI BMPs should be selected based on the goals of each project and site, depending on which ecosystem services should be prioritized. For this project site at UMass Amherst, of the ecosystem services previously discussed, water quality, pollutant removal, and reduced urban heat island will be prioritized, while balancing the aesthetic and user needs of the college campus.

## PERFORMANCE MONITORING

### 4.1 Performance Monitoring Programs & Guidelines

In order to begin to test whether green infrastructure is really doing what some of the research is beginning to claim that it does, various performance monitoring programs and guidelines have emerged. For example, at the municipal scale, several cities have initiated Green Streets programs that have a monitoring programs component to them including: NYC Green Infrastructure, Philadelphia Water Department, Milwaukee Metropolitan Sewerage District, Boston Complete Streets. On the site scale, new performance monitoring guidelines are also being employed throughout the country (e.g. Living Building Challenge, the Sustainable Sites Initiative, and the Landscape Architecture Foundation’s Landscape Performance Series (LPS). Of particular importance to this master’s project is the Sustainable Sites Initiative guidelines, which will be integrated into this master’s project.

The Sustainable Sites Initiative (SITES) is a program accredited by Green Business Certification Inc. (GBCI), an organization that strictly accredits certificates within the sustainability industry. SITES is used by planners, policy makers, landscape architects, developers, engineers, architects, and

designers to guide sustainable land development. SITES promotes the implementation of designs that protect the integrity of ecosystem services upon which life depends. SITES considers the integrity of soil, water, vegetation, materials and human health and evaluates a project site’s potential to help with climate regulation, flood mitigation, and carbon sequestration. Landscapes certified by SITES help “reduce water demand, filter and reduce stormwater runoff, provide wildlife habitat, reduce energy consumption, improve air quality, improve human health and create outdoor recreation opportunities” (SITES). SITES provides a comprehensive way to measure the performance of sustainable landscapes and to improve their value.

Rather than prescribe a specific practice, SITES provides a rating system that is adaptable to the conditions of each unique site. The certification is “based on a point system: the number of points that a project earns determines the certification level it receives. The SITES certification process allows projects to benchmark against performance criteria. The process is performed through SITES Online, which is a simplified tool to allow designed to collect documentation and track projects from start to finish” (<http://www.sustainablesites.org/>). SITES can be both new and existing, but the project must have been built within the past two years and the site must be at least 2,000 square feet. Categories for project sites include: commercial, residential, institutional/educational, streetscapes and plazas, and open spaces (<http://www.sustainablesites.org/>; accessed 1.25.16).

SITES follows assigns a point system for 10 different categories, which are broken into sections. The sections are as follows:

1. Site Context
2. Pre-Design Assessment & Planning
3. Site Design – Water
4. Site Design – Soil & Vegetation
5. Site Design – Materials Selection



## **SITES GOALS**

### **Create Regenerative Systems and Foster Resiliency**

- Protect and restore natural resources such as soil, water, and vegetation.
- Encourage biodiversity.
- Enhance landscapes to provide multiple ecosystem services such as cleaning air and water, providing habitat, and storing carbon.
- Mitigate for evolving hazards and natural disasters.
- Plan for monitoring and adaptive management.

### **Ensure Future Resource Supply and Mitigate Climate Change**

- Minimize energy consumption and encourage use of low carbon and renewable energy sources.
- Minimize or eliminate greenhouse gas emissions, heavy metals, chemicals, and other pollutants.
- Reduce, reuse, recycle, and upcycle materials and resources.
- Conserve water.
- Increase the capacity of carbon sinks through re-vegetation.

### **Transform the Market through Design, Development, and Maintenance Practices**

- Foster leadership in industry and professional practice.
- Use a systems-thinking, integrative and collaborative design approach.
- Use lifecycle analyses to inform the design process.
- Support local economies and sustainability policies.

### **Enhance Human Well-Being and Strengthen Community**

- Reconnect humans to nature.
- Improve human health (physical, mental, and spiritual).
- Foster stewardship by providing education that promotes the understanding of natural systems, and recognizes the value of landscapes.
- Encourage cultural integrity and promote regional identity.
- Provide opportunities for community involvement and advocacy.

*SITES v2, 2014, p. xii*

6. Site Design – Human Health & Well Being
7. Construction
8. Operations & Maintenance
9. Education & Performance Monitoring
10. Innovation or Exemplary Performance

While all of these sections are important to a sustainable design, for the purposes of this master's project, only some of the sections will be applied. See the Methodology chapter for more information.

SITES offers a comprehensive set of sustainability standards and guidelines that help make a landscape design sustainable and resilient. By following some of these guidelines, UMass Amherst may be able to create resilient stormwater management infrastructure on campus that can reduce costs and improve water quality, while also making comfortable spaces for students to mingle, creating striking views and formal entrances, and improving pedestrian circulation.

### **Landscape Architecture Foundation: Landscape Performance Series**

The Landscape Architecture Foundation (LAF) supports the Sustainable SITES Initiative and offers monitoring tools to measure the landscape's performance. LAF defines landscape performance as "a measure of the effectiveness with which landscape solutions fulfill their intended purpose and contribute to sustainability." As stated on the LAF website, "no matter how sustainability is defined – zero carbon, net zero water, biodiversity, quality of life – it cannot be achieved without considering landscape". In order to progress as a profession, LAF purports that built landscapes need to be monitored and evaluated in order to assess the success of the landscape's planning and design. LAF believes that in studying the "connections between landscape and the health of ecosystems, people, and economies, we increase our understanding and our collective capacity to achieve environmental, social, and economic sustainability."

As more planners and designers begin to embrace this process, the body of literature relating to performance monitoring will grow, and ultimately provide a platform to “inform public policy, reduce investor risk, and improve return on investment.”

LAF created the Landscape Performance Series (LPS) as a way to establish a base for information sharing and research. LPS “was developed to build capacity to achieve sustainability and transform the way landscape is considered in the design and development process”. LPS serves as a base for “innovations from research, industry, academia, and professional practice.” LPS is intended to be used by planners and designers to showcase case study precedents, monitoring techniques, and further areas of research. The website offers meaningful methods to both quantitatively and qualitatively measure the performance of landscape’s ability to provide environmental, social and economic benefits. In this way LAF advocates and advances for the designing, planning, and building of sustainable landscapes. (<http://landscapeperformance.org/about-landscape-performance>; accessed 1/3/2016).

## CONCLUSION

The literature review provides the background information upon which design decisions will be based. By reviewing literature which demonstrates the need for ecological stormwater management, the evolution of sustainable planning and design, and the emerging field of landscape performance monitoring, answers to the research questions begin to emerge, and subsequently the design direction.

UMass Amherst has begun to reassess its relationship to sustainability and is in the process of developing sustainability in practice. Based on the literature review, it is clear that conventional stormwater management, which dominates campus, is causing

unsustainable environmental degradation. As UMass Amherst is much like its own municipality and therefore its own urban ecosystem, the university would benefit from building a resilient network of green stormwater infrastructure on campus.

Green stormwater infrastructure provides a suite of ecosystem services and a myriad of social/economic purposes. GSI improves water quality, reduces impacts on receiving water bodies, cools the air, contributes to creating biodiversity and habitat, provides psychological benefits to users, and all the while helps campus meet the EPA’s MS4 regulation requirements. While site assessment will further inform the specific needs and possibilities of this project’s site, UMass Amherst as a campus would benefit from utilizing the adaptive management to the planning and design of green stormwater infrastructure on campus.

Campus Planning would benefit from piloting a green stormwater infrastructure demonstration site planned and designed using sustainability and performance monitoring guidelines. In this way, Campus Planning can make informed planning and design decisions regarding the integration of GSI into its conventional stormwater management on campus, and adapt its application over time. Much like the Landscape Performance Series, in accumulating research and records of GSI efficacy and landscape performance, the University could create a knowledge base that would help inform which BMPs to use where and how to maintain them over time. Campus could design ways of measuring ecosystem service benefits, thus re-envisioning a new set of values upon which design decisions can be based, paving the way for a more resilient campus.



# CASE STUDIES

Investigating project precedents was an integral part of the methodology and design process. While there are many projects that integrate green infrastructure performance guidelines and artful stormwater management, projects were selected based on relevance to a set of criteria similar to the project site. Project site selection criteria was based on: location/climate, scale/size, as well as the integration of performance/sustainability guidelines, the artful display of stormwater, and educational opportunities. Only municipal or institutional sites were considered, as the proposed site will be a municipal landscape.

The sites selected are as follows:

- Shoemaker Green; Philadelphia, PA
- Queens Botanical Gardens; Flushing, NY
- Marsh Hall; Salem, MA
- Ridge & Valley at Penn State Arboretum; University Park, PA

## SHOEMAKER GREEN

**Date:** 2012

**Size:** 2.85 acres

**Location:** UPenn, Philadelphia

**Owner:** University of Pennsylvania

**Designers:** Andropogon Associates; Meliora Design

**Keywords:** SITES certified, ecosystem services, green infrastructure, landscape architecture, multi-functional

**Background:** This SITES Certified project is a transformed greyfield at the core of the University of Pennsylvania's campus. Prior to the site's development, Penn had made a commitment to campus sustainability. In conjunction with meeting the City's Green City, Clean Water program goals, Penn decided the site's renovation would exhibit sustainable design. The design team collaborated with the Earth and Environmental Science Department to develop a long-term monitoring program for the site (Echols and Pennypacker, 2015, p. 248-252).



[http://www.pennconnects.upenn.edu/all\\_project\\_images/shoemaker\\_green\\_images/shoemaker\\_overview.jpg](http://www.pennconnects.upenn.edu/all_project_images/shoemaker_green_images/shoemaker_overview.jpg)



<https://landingarchitecture.files.wordpress.com/2013/03/07-benches.jpg>



**Design overview:** Sitting in front of important campus buildings, and along a public ROW, Shoemaker Green is a grassy quad, surrounded by seating and shaded gathering areas. A system of runnels discharge into a dry creek bed surrounded by a naturalized rain garden. Step stones allow curious passersby the opportunity to intersect the path of water flow using step stones through the dry creek channel. According to the designers, the site is capable of infiltrating “3.14” storm at a minimum, which is well above the design requirement of the site to manage a 1” storm” (Echols and Pennypacker, 2015, p. 250). Below the site a 20,000 gallon cistern below the site captures roughly 124,000 gallons of stormwater a year (Echols and Pennypacker, 2015, p. 248-252).

**Significance, impact, and lessons learned:** Penn’s decision to make Shoemaker Green a pilot SITES landscape has drawn the campus into the limelight of sustainable planning and design. The site is also visually striking, providing inviting views to the public from 33rd Street, which runs along its western border. The site succeeds in feeling like a campus quad, which at the same time providing enormous amount of stormwater storage (Echols and Pennypacker, 2015, p. 248-252). The importance of creating a interdisciplinary design team was integral to the long-term success of this project. While most of the aesthetic of Penn is manicured, the naturalized rain garden on the site works nicely within its confined location, and could serve as a model for creating more ecologically landscaped areas (Echols and Pennypacker, 2015, p. 248-252).



Photo credit: Nelle Ward (2016)



Photo credit: Nelle Ward (2016)





*Photo credit: Nelle Ward (2016)*



*Photo credit: Nelle Ward (2016)*



*Photo credit: Nelle Ward (2016)*



## MARSH HALL QUAD

**Date:** 2010

**Size:** 3,000 sq ft

**Location:** Salem, MA

**Owner:** Salem State University

**Designers:** WagnerHodgson Landscape Architecture

**Keywords:** stormwater, multi-functional, stormwater, green infrastructure, LEED

**Background:** In order to compliment a brand new LEED Gold certified residential dormitory on the site, Salem State wanted to create a complimentary sustainable landscape. Formerly an industrial site suffering from extreme compaction, the landscape (later to become Marsh Hall) was in need of remediation. Soil borings exhibited lack of biological activity and impermeability. Located near an existing salt tidal marsh, yet seemingly completely isolated from it, the site presented an opportunity to re-connect with the natural surrounding landscape ("Salem State", 2015).

**Design overview:** A central grassy quad is surrounded by a marsh-like linear bioswale, and pedestrian seating. The quad serves as an opportunity for recreation and is graded at an angle to direct stormwater into the bioswale. Wood and steel boardwalks pass over a 180' bioswale, hosting native rushes, grasses, and sedges running along the edge of the recreational plane. The gabions surrounding the quadrangle direct stormwater into the sunken quad. Some of the gabions are capped with wood to serve as seating for pedestrians using the main walkway. Stormwater from two neighboring courtyards and 41,000 sqft of roof and plaza area is directed into the linear bioswale. The bioswale hosts native vegetation that cleanses pollutants out of the stormwater as it infiltrates. The overflow exits the site through a raised catch basin. Stormwater that leaves the site enters the existing salt marsh ("Salem State", 2015).



<http://www.wagnerhodgson.com/projects/educational/salem-state-university-marsh-hall>



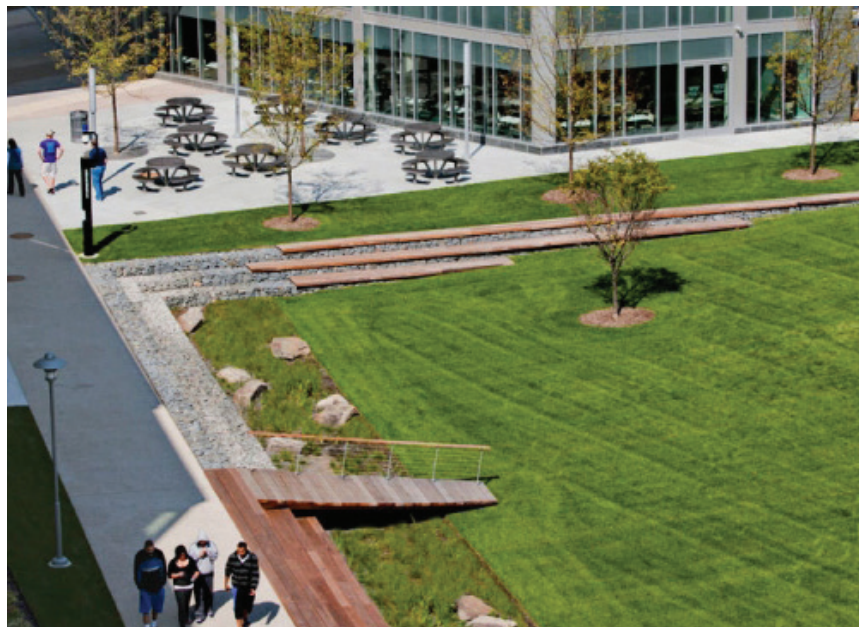
<http://www.wagnerhodgson.com/projects/educational/salem-state-university-marsh-hall>



**Significance, impact and lessons learned:** This project showed Salem State that seemingly conflicting goals can coexist and be met in the same place at the same time. Marsh Hall shows that stormwater management can be a central campus feature that receives everyday use by students. Meanwhile, the formal context of the campus is not compromised. This unobtrusive, and somewhat disguised means of ecologically managing stormwater passively educates the site's users and re-connects the site to the surrounding ecological systems. At the same time, Marsh Hall quad provides pedestrian amenities and recreational opportunities.



<http://www.wagnerhodgson.com/projects/educational/salem-state-university-marsh-hall>



<http://www.wagnerhodgson.com/projects/educational/salem-state-university-marsh-hall>



<http://www.wagnerhodgson.com/projects/educational/salem-state-university-marsh-hall>



## RIDGE & VALLEY AT PENN STATE ARBORETUM

**Date:** 2009

**Size:** 924 sqft

**Location:** University Park, PA

**Owner:** Penn State

**Designers:** Stacy Levy with MTS Landscape Architects;  
Overland Partners

**Keywords:** stormwater, artful rainwater, watershed,

**Background:** In 2007, Penn State's arboretum was sited above a major aquifer within the Spring Creek watershed. Because groundwater embedded within underground karst caverns provided the main source for potable water for the area, a landscape design which educated and protected this important resource was proposed. A collaborative effort between landscape architects, artists, and architects resulted in a beautiful, but educational display of hydrology (Echols and Pennypacker, 2015, p. 182-186).

**Design overview:** A terrace, adjacent to a pavilion that overlooks part of the botanical gardens, offers a to-scale map of the Spring Creek watershed. The map is comprised of rivers and lakes etched into bluestone on the ground plane. Roof rainwater from the pavilion is channeled into a scupper, then drops onto the map and then follows the path of water through the watershed map. Then the water flows into a wet meadow infiltration basin that recharges Penn State's well fields. Naturally shaped stones surrounding the terrace provide seating and play spaces for children (Echols and Pennypacker, 2015, p. 182-186).

**Significance, impact, and lessons learned:** The interactive map is beautiful in both wet and dry conditions, allowing the utility of the this stormwater feature to educate without the presence of stormwater flow. The map educates users about watershed dynamics and the presence of the recharging the



[http://artfulrainwaterdesign.psu.edu/sites/default/files/6.\\_stacy\\_levy\\_scupper\\_2m\\_1920\\_copy\\_0.jpg](http://artfulrainwaterdesign.psu.edu/sites/default/files/6._stacy_levy_scupper_2m_1920_copy_0.jpg)



[http://stacylevy.com/installations/images/ridge\\_and\\_valley-1.jpg](http://stacylevy.com/installations/images/ridge_and_valley-1.jpg)



aquifer below the surface. The terrace is visible from the Visitor's Center, where restrooms and other amenities are located, increasing the likelihood of the map being explored. The collaborative effort of reaching across disciplines resulted in a functional, structurally sound model for interdisciplinary design and learning (Echols and Pennypacker, 2015, p. 182-186).



[http://assets.inhabitat.com/wp-content/blogs.dir/1/files/2012/01/stacy-levy-ridge\\_and\\_valley-2-large1.jpg](http://assets.inhabitat.com/wp-content/blogs.dir/1/files/2012/01/stacy-levy-ridge_and_valley-2-large1.jpg)



<http://artfulrainwaterdesign.psu.edu/project/ridge-and-valley-penn-state-arboretum>



<https://arboretum.psu.edu/wp-content/uploads/2014/04/Ridge-And-Valley-A.-Capinski.jpg>





CHAPTER 3

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METHODOLOGY



# METHODOLOGY

## OVERVIEW

The methodology employed for this Master's Project is represented in the following chapters: Literature Review, Case Studies, Site Analysis, Site Design, and Site Planning. Each of the chapters integrates the mission and/or guidelines of the Sustainable SITES Initiative v2 (SITES). The application of the guidelines is further explained within each chapter. The complete list of SITES chapters are listed below; however, some chapters are greyed out as they were not relevant to this project's design process.

### Sustainable SITES Initiative Chapters

SECTION 1: Site Context  
SECTION 2: Pre-Design Assessment & Planning  
SECTION 3: Site Design – Water  
SECTION 4: Site Design – Soil & Vegetation  
SECTION 5: Site Design – Materials  
SECTION 6: Site Design – Human Health/Well Being  
SECTION 7: Construction  
SECTION 8: Operations & Maintenance  
SECTION 9: Education & Performance Monitoring  
SECTION 10: Innovation or Exemplary Performance

## LITERATURE REVIEW & CASE STUDIES

The Literature Review provided the background information that demonstrates the need for a new approach to sustainable planning and design. The review discusses the impacts of conventional stormwater management, the benefits of green stormwater infrastructure and ecosystem service-based design, and it introduces the reader to relevant performance guidelines. Finally, the literature review briefly describes the history of the Sustainable SITES Initiative, and how project sites become SITES certified.

The case studies were presented at the level of depth consistent with the "Abstract/Factsheet" criteria from the Landscape Architecture Foundation's A Case Study Method for Landscape Architecture by Mark Francis. The information necessary to meet "Abstract/Factsheet" Case Study criteria includes:

- Photos,
- Project background
- Project significance and impact
- Lessons learned
- Contact
- Keywords (Francis, 1999)

Case study projects were selected based on relevance to the project site using the following criteria:

- Location/climate
- Scale/size

- Use of sustainability guidelines (preference given to Sustainable SITES Initiative certified projects)
- Artful display of stormwater
- Educational opportunity
- Institutional/Municipal

Case study reviews were used to identify successfully applied practices for designing legible, educational, and effective green infrastructure systems. The case studies were also used for artistic inspiration, to identify performance monitoring techniques, and as examples of long term planning strategies for site operations, maintenance, and user engagement.

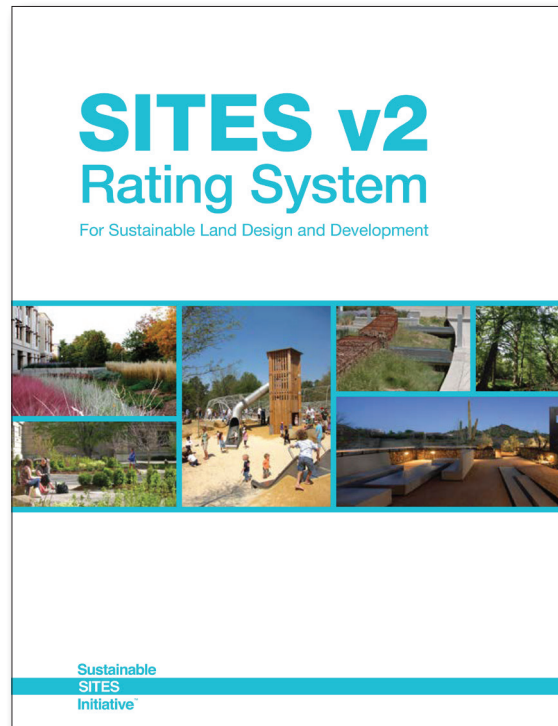
*Francis, Mark. A Case Study Method for Landscape Architecture. Publication. Washington, DC: Landscape Architecture Foundation, 1999. Print.*

## SITE ASSESSMENT

Site Assessment chapter analyzed the project site from the watershed scale to detailed site scale. The Site Assessment chapter used guidelines from the following Sustainable SITES Initiative chapters:  
SECTION 1: Site Context  
SECTION 2: Pre-Design Assessment & Planning

The Site Assessment process included spatial analyst tools including Geographic Information Systems (GIS) and other online mapping systems as mandated by the SITES initiative guidelines. Site level analysis was conducted through observation, reference to existing reports, and conversations with Campus Planning.

The Sustainable SITES Initiative guidelines mandate that the project site be measured against pre-requisites and credits for the Site Selection and Pre-Design Assessment & Planning chapters described below.



*Sustainable SITES v2 cover (2014)*





**Credits** (p. 26):

- Water C3.3 Manage precipitation beyond baseline (4-6 pts)
- Water C3.4 Reduce outdoor water use (4-6 pts)
- Water C3.5 Design functional stormwater features as amenities (4-6 pts)
- Water C3.6 Restore aquatic ecosystems (4-6 pts)

**SECTION 4: Site Design – Soil & Vegetation**

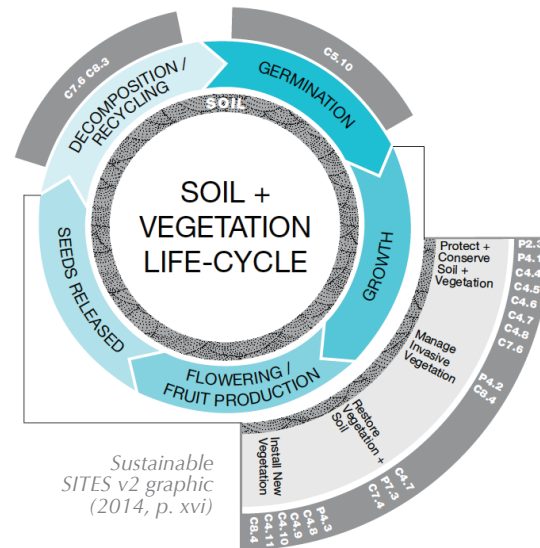
Section 4 brings attention to the importance of developing a proper soil management plan to ensure the long-term health of a site. Healthy soils, aside from allowing vegetation to thrive, “filter pollutants and help prevent excess runoff, erosion, sedimentation, and flooding. Using appropriate vegetation, managing invasive plants, and restoring biodiversity (emphasizing native species) are some “key strategies that have multiple environmental, economic, and social benefits” (p. xvi). Healthy soils “can reduce or eliminate landscape irrigation, increase the quality of wildlife habitat, promote regional identity, and reduce maintenance needs” (p. xvi).

**Perequisites** (p. 37):

- Soil+Veg P4.1 Create and communicate a soil management plan
- Soil+Veg P4.2 Control and manage invasive plants
- Soil+Veg P4.3 Use appropriate plants

**Credits** (p. 37):

- Soil+Veg C4.4 Conserve healthy soils and appropriate vegetation (4-6 pts)
- Soil+Veg C4.5 Conserve special status vegetation (4 pts)
- Soil+Veg C4.6 Conserve and use native plants (3-6 pts)
- Soil+Veg C4.7 Conserve and restore native plant communities (4-6 pts)
- Soil+Veg C4.8 Optimize biomass (1-6 pts)



- Soil+Veg C4.9 Reduce urban heat island effects (4 pts)
- Soil+Veg C4.10 Use vegetation to minimize building energy use (1-4 pts)
- Soil+Veg C4.11 Reduce the risk of catastrophic wildfire (4 pts)

**SECTION 6: Site Design – Human Health/Well Being**

Section 6 focuses on ensuring that the site considers the importance of access to green space as it relates to psychological well being. As stated in the SITES v2 document, “whether in a park or natural area, or simply viewing green space during daily life, positively affects mental health and facilitates social connection. These effects are essential to healthy human habitat and extend to include positive physical health outcomes” (p. xviii). The guidelines reward the creation of “outdoor opportunities for physical activity, restorative and aesthetic experiences, and social interaction. It also encourages projects to address social equity in their design and development choices” (p. xviii). The guidelines

thereby promote designs that help build stronger communities and environmental stewardship.

**Credits** (p. 69):

- HHWB C6.1 Protect and maintain cultural and historic places (2-3 pts)
- HHWB C6.2 Provide optimum site accessibility, safety, and wayfinding (2pts)
- HHWB C6.3 Promote equitable site use (2 pts)
- HHWB C6.4 Support mental restoration (2 pts)
- HHWB C6.5 Support physical activity (2 pts)
- HHWB C6.6 Support social connection (2 pts)
- HHWB C6.7 Provide on-site food production (3-4 pts)
- HHWB C6.8 Reduce light pollution (4 pts)
- HHWB C6.9 Encourage fuel efficient and multi-modal transportation (4 pts)
- HHWB C6.10 Minimize exposure to environmental tobacco smoke (1-2pts)
- HHWB C6.11 Support local economy (3 pts)

**SECTION 8: Operations & Maintenance**

In order to ensure the long-term performance goals in relation to providing ecosystem services, this section guides designers to think about the conservation of resources, the reduction of pollution, and the realities of working with a maintenance team throughout the design process. For example, “strategies include reducing material disposal, ensuring long-term health of soil and vegetation, reducing pollution, conserving energy, and encouraging the use of renewable energy” (p. xviii).

**Prerequisites** (p. 99):

- O+M P8.1 Plan for sustainable site maintenance
- O+M P8.2 Provide for storage and collection of recyclables

**Credits (p. 99):**

- O+M C8.3 Recycle organic matter 3-5 pts)
- O+M C8.4 Minimize pesticide and fertilizer use 4-5 pts)
- O+M C8.5 Reduce outdoor energy consumption 2-4 pts)
- O+M C8.6 Use renewable sources for landscape electricity needs 3-4 pts)
- O+M C8.7 Protect air quality during landscape maintenance 2-4 pts)

**SECTION 9: Education & Performance Monitoring**

These guidelines reward site designs that include “efforts made to inform and educate the public about the project goals and sustainable practices implemented in site design, construction, and maintenance” (p. xviii). In doing so, the section creates “an incentive to monitor, document, and report the performance of the site over time in order to influence and improve the body of knowledge in site sustainability” (p. xviii).

**Credits (p. 113):**

- Education C9.1 Promote sustainability awareness and education (3-4 pts)
- Education C9.2 Develop and communicate a case study (3 pts)
- Education C9.3 Plan to monitor and report site performance (4 pts)



*Shoemaker Green - A Sustainable SITES certified landscape*

<http://androblogon.tumblr.com/post/29984537955/shoemaker-green-at-the-university-of-pennsylvania>

CHAPTER 4

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SITE ASSESSMENT

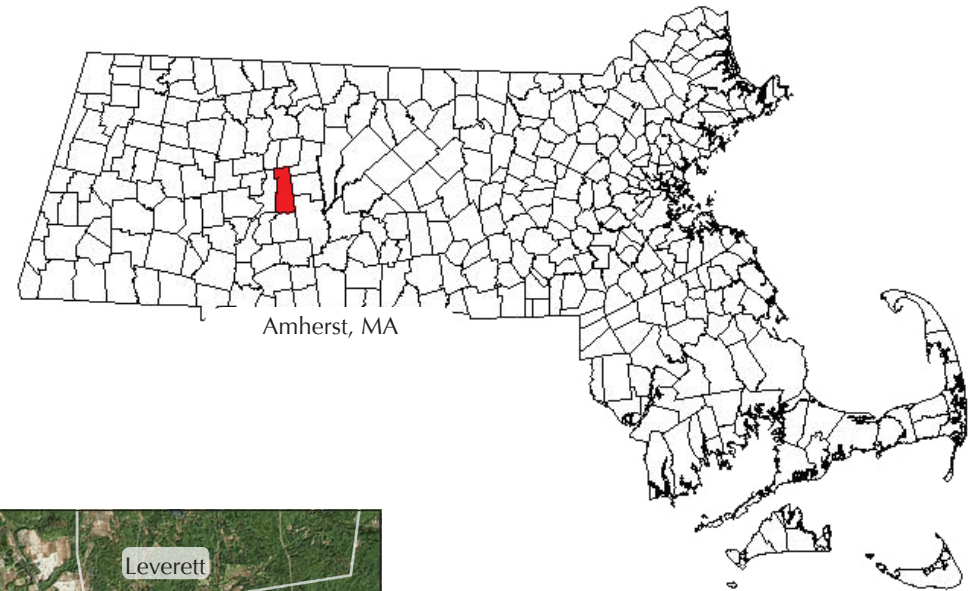




# SITE ASSESSMENT

## OVERVIEW

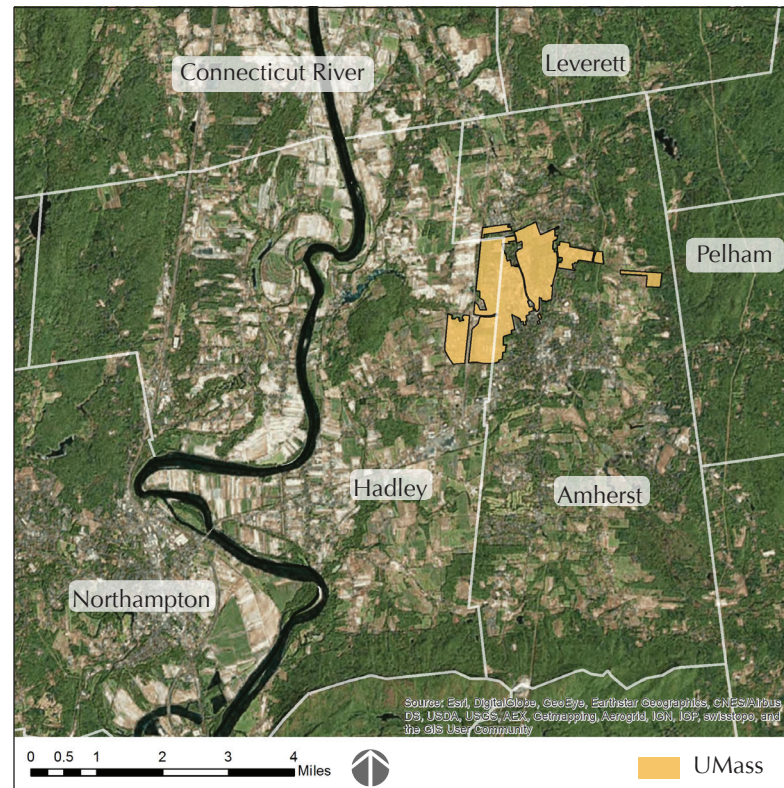
This site assessment chapter moves from larger, regional scale to detailed site scale analysis. The site assessment first introduces Amherst, MA and its contextual geography and ecology. Zooming in, surrounding building use and existing plans are discussed followed by slopes, drainage, stormwater infrastructure, soils, vegetation, and circulation.



## LOCATION

The project site is located in Amherst, MA. Amherst, MA is located east of the Connecticut River, and close to the neighboring towns of Hadley, Northampton, Leverett, and Pelham. Amherst and Northampton are relatively urban areas compared to the surrounding patchwork of mostly rural agrarian towns.

The University of Massachusetts is just north of downtown Amherst. The population of Amherst is about 38,000 (2010) and roughly 30,000 are students. Amherst, therefore experiences seasonal population loss. Students coming from all over the country and the world comprise a thriving young, population, that travels back and forth from UMass to downtown Amherst with weekend adventures to Northampton.



<http://www.hercampus.com/hcs-complete-college-guide/university-massachusetts-amherst>



## CAMPUS CONTEXT

### Cultural Significance

The project site sits in front of the Fine Arts Center (FAC) and at the end of Haigis Mall, the “Gateway to campus”. Haigis Mall connects to Massachusetts Avenue to the south, and North Pleasant Street runs along the site’s eastern border; both streets are public ROWs. The site is about 3.2 acres or 142,000 sqft of gently sloping turf and paved paths.

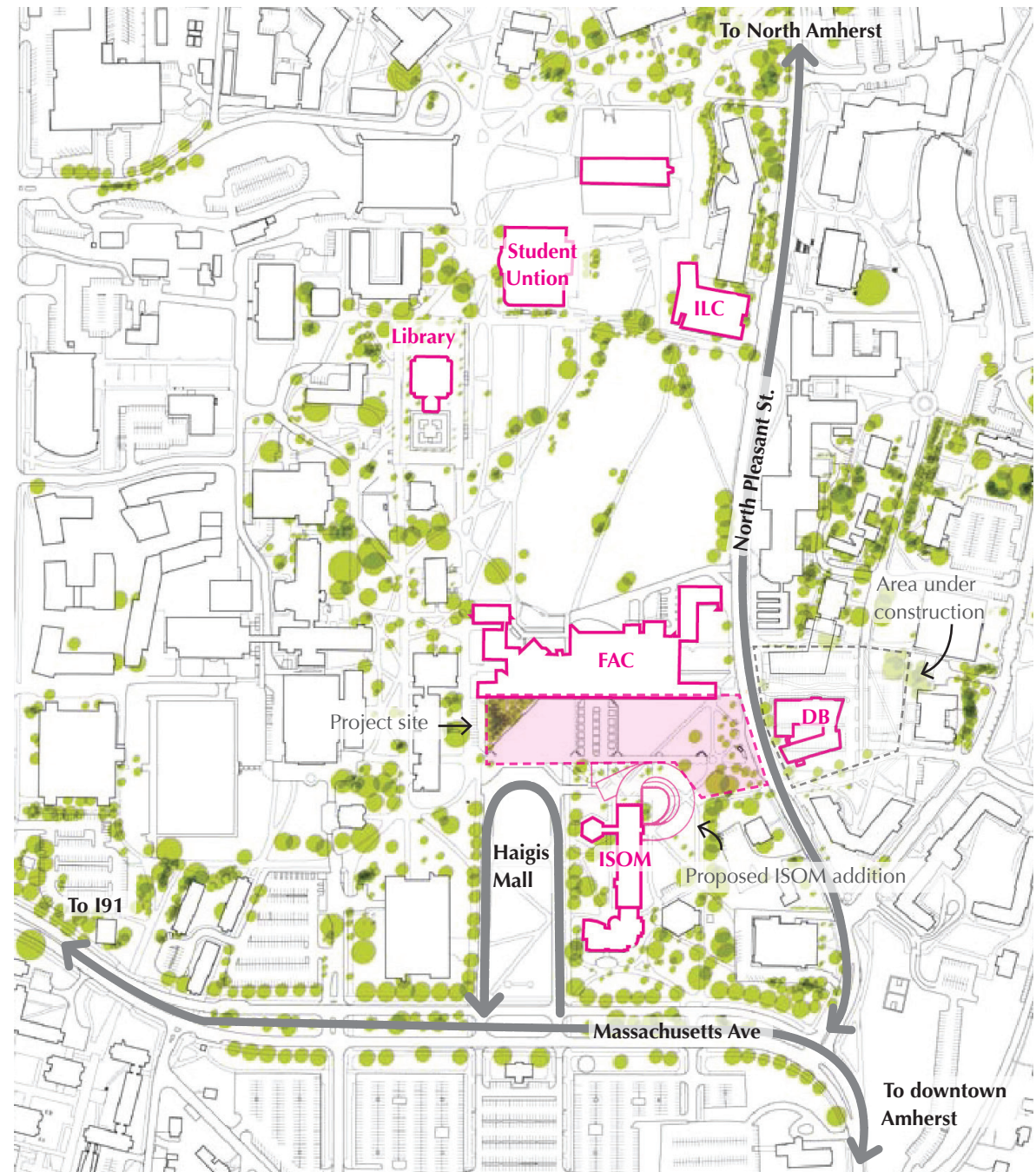
### Surrounding Buildings

The FAC is an iconic and significant building on campus, visible to the public from both Massachusetts Ave and North Pleasant Street. Influxes of visitors occur during occasional events that the FAC hosts. The Design Building, which is currently under construction opening Spring 2017, sits directly east of the site with overlooking views. The Isenberg School of Management sits south of the site. The site is in a central location, close to the Dubois Library, the Student Union, and the Integrated Learning Center.

### Future Developments

The new Design Building, as well a not-yet-built addition to the Isenberg School of Management will significantly change the way the site is used, perceived, and possibly the degree to which it is viewed by visitors.

The Design Building (DB) is a \$52 million investment intended to showcase the University’s commitment to Sustainability and innovation. The DB will attempt LEED Platinum certification, exhibiting a green roof on the third floor, and rainwater harvesting bioswales around the base of the building. The 87,000 sqft four-story building features eco-friendly building materials. Instead of energy-intensive concrete-steel construction, the glue-laminated wood, cross-laminated timber, and wood-concrete composite structure is made from underutilized, local, native





wood (Lederman, 2016). The Design Building will host the Architecture, Landscape Architecture, and Building Construction Technology programs. The building will likely attract visitors and publicity once completed.

The southern site edge will be influenced by new ISOM addition. UMass contracted with BIG Architects from NYC to add a dramatically shaped circular addition to the ISOM. The final plans and construction date are not yet known. Planning is still in process.

Consideration of the use of these two proposed building, the FAC, and the site's relationship to the rest of campus should be integral to the proposed landscape design.



<http://www.umassonthemove.net/wp-content/uploads/2015/12/UMADBheader.png>



<https://www.umass.edu/dcm/sites/default/files/IDB%20from%20Stockbridge.jpg>



GoodyClancy/BIG Design Concepts Proposal; Jan. 2016



GoodyClancy/BIG Design Concepts Proposal; Jan. 2016

## ECOLOGICAL CONTEXT

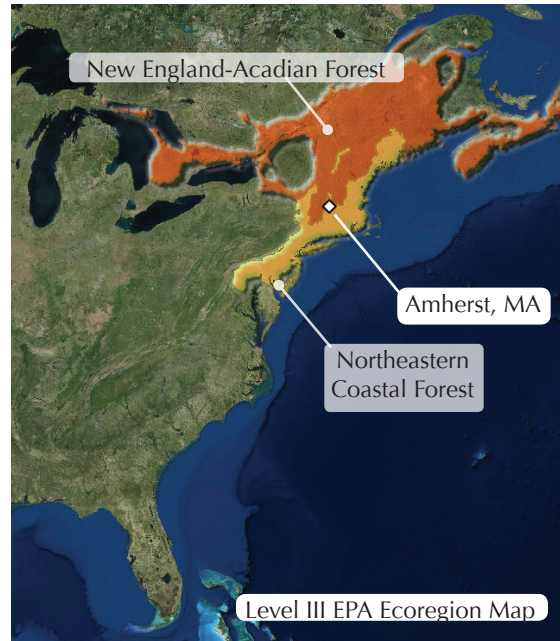
Amherst, MA is located on the eastern side of the United States. Amherst is within the Temperate Broadleaf and Mixed Forest Terrestrial Biome and the Northeastern Coastal Forest Ecoregion (Zone: Connecticut Valley 59A). It is situated on the edge of another ecoregion, the New-England-Acadian Forests. (SITES PR/Credits: Level III EPA Ecoregion Map: C4.6, C4.7a)

The Northeastern Coastal Forest is dominated by Appalachian oak forests. The oak plant communities blend into mixed deciduous communities on the lower northern slopes and within ravines. The species composition may include either elements of the oak forest or those of the northern hardwood-conifer forest, varying widely depending on soil conditions and microclimate. (SITES PR/Credits: C4.8)

## CLIMATE

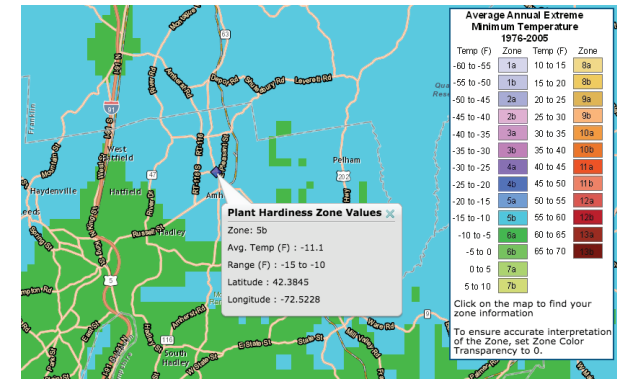
By 2100, temperatures could increase by about 4 degrees in winter and spring and about 5 degrees in summer and fall. By 2100, precipitation is estimated to increase by about 10 percent in spring and summer, 15 percent in fall, and 20 to 60 percent in winter. The Plant Hardiness zone is currently 5B (average annual minimum temperature of -15 to -10 F, but could become 6A over time).

The contextual native plant communities in conjunction with the changing climate should be taken into consideration in the proposed landscape design. Designs which feature native plants that can adapt to both drought and intense rain fall should be selected.

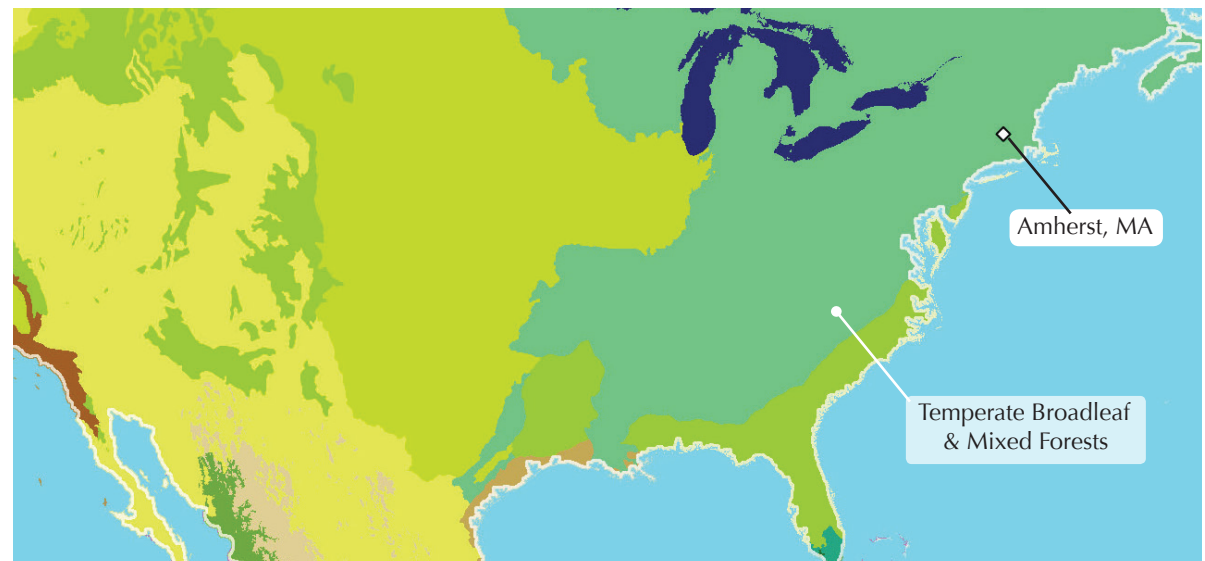


<http://www.worldwildlife.org/science/wildfinder/>

Month	Jan.	Feb.	Mar.	Apr.	May	June
Av. high (F)	33	36	46	58	70	78
Av. low (F)	11	13	24	34	45	54
Av. percip (in)	3.78	2.83	3.58	3.82	4.09	3.82
Month	July	Aug.	Sept.	Oct.	Nov.	Dec.
Av. high (F)	83	81	73	62	49	38
Av. low (F)	59	5	49	36	28	18
Av. percip (in)	3.94	4.09	4.06	3.98	3.94	3.62



<http://planthardiness.ars.usda.gov/PHZMWeb/InteractiveMap.aspx>



<http://www.worldwildlife.org/science/wildfinder/>



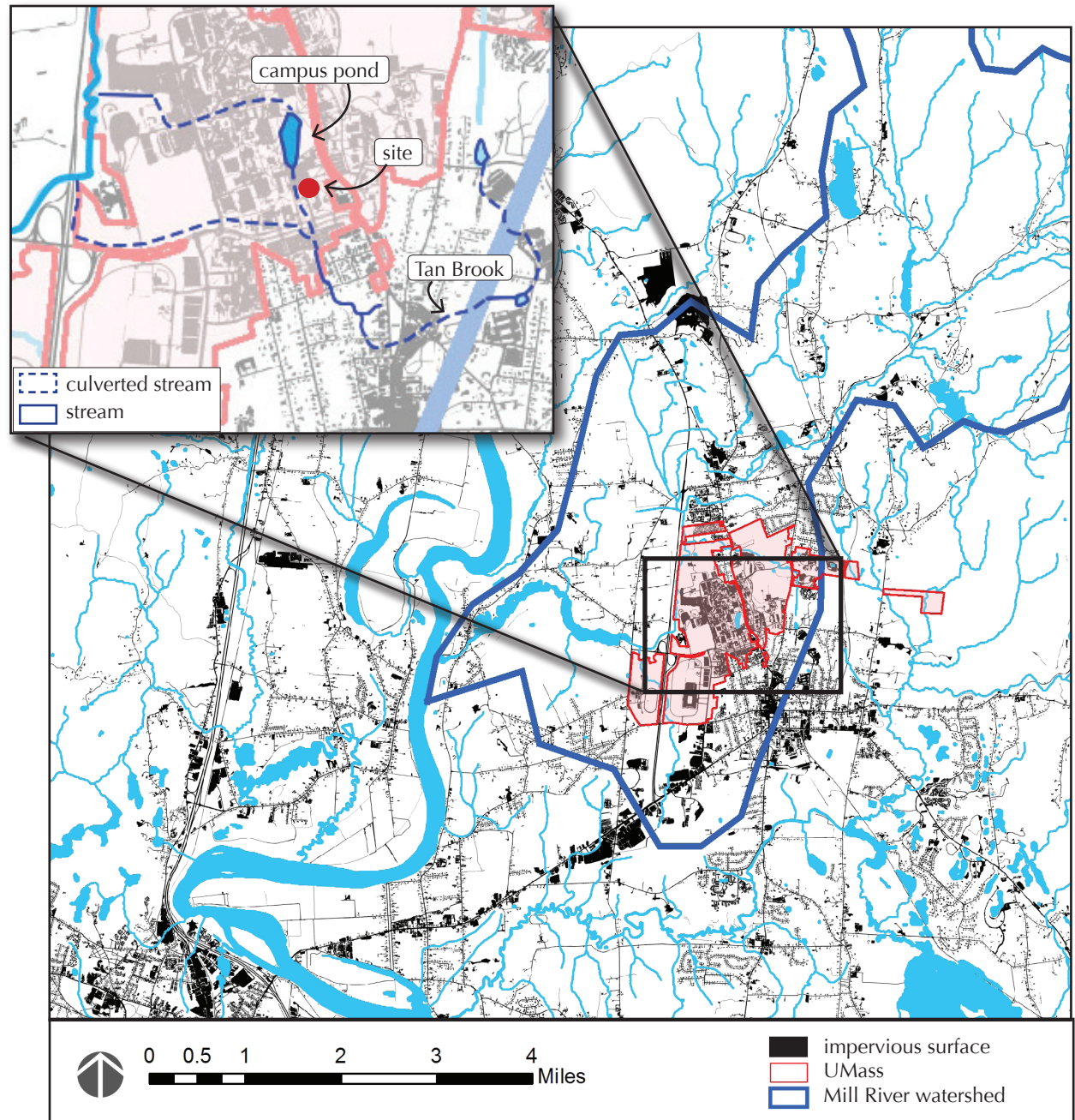
## WATERSHED & IMPERVIOUS SURFACE

UMass Amherst is located within the Mill River watershed, which discharges into the Connecticut River. Downtown Amherst and UMass Amherst are designated Municipal Separate Storm Sewer Systems (MS4s). MS4s are obligated to apply for National Pollutant Discharge Elimination System (NPDES) Phase II permits in order to discharge polluted stormwater runoff into receiving waterbodies.

Tan Brook is culverted under parts of downtown Amherst and then under UMass campus. Much of the storm drain infrastructure, including culverted Tan Brook, combines at the campus pond, and then continues into overflow infrastructure that eventually discharges the mixed, polluted stormwater runoff, into the Mill River. UMass Amherst therefore receives untreated polluted stormwater runoff from impervious downtown Amherst. Because UMass Amherst is densely impervious itself, the ecological integrity of the Mill River is compromised.

The Campus Pond is a major stormwater management feature on campus, and therefore the integrity of the pond is compromised. Water quality test results from Spectrum Analytical (2009) indicated high levels of lead, heavy metals, E. coli, turbidity, phosphorus, and nitrogen. Though UMass is an MS4, there is currently no protocol to testing stormwater quality on campus, but under the 2016 NPDES regulations, this will have to change.

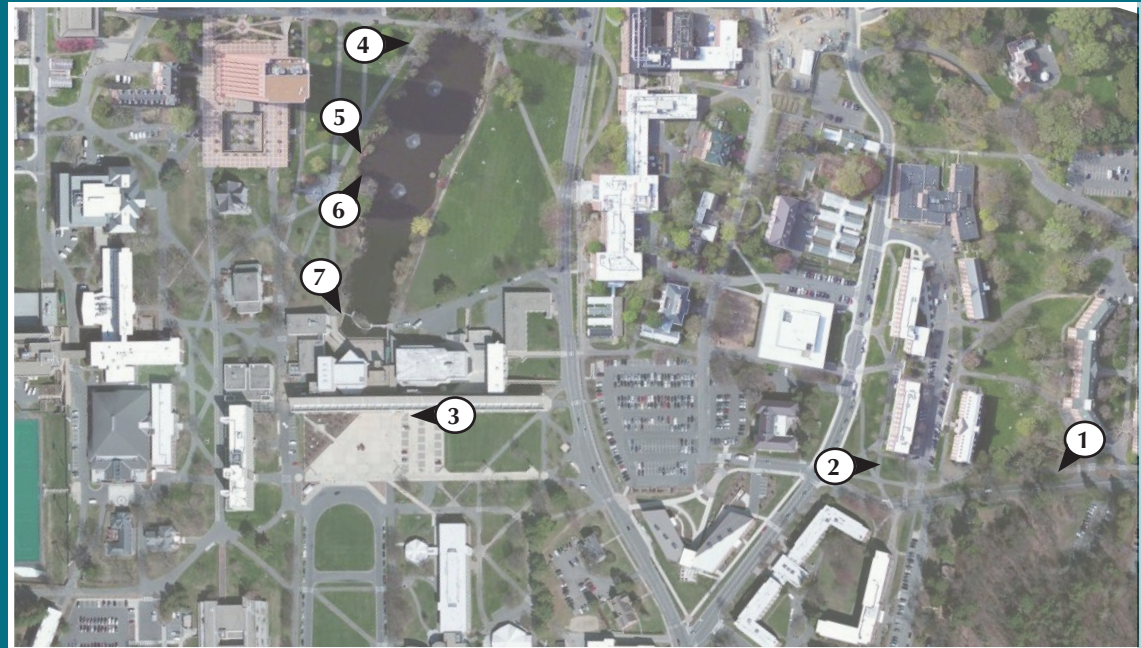
New NPDES regulations (2016) will require UMass to decrease impervious surface over time, integrated green infrastructure/best-management-practices, and have a Public Education and Outreach program to teach residents and students about the environmental impact of urban hydrology (see p. 5-6 for more details).



Source: Geographic Information Systems



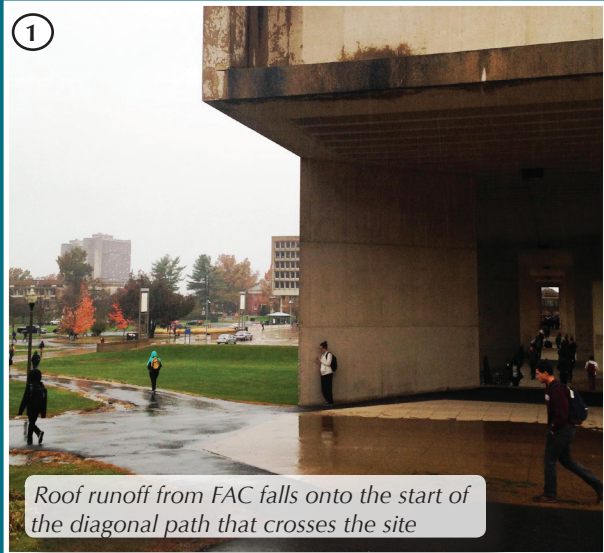
## IMPERVIOUS SURFACE











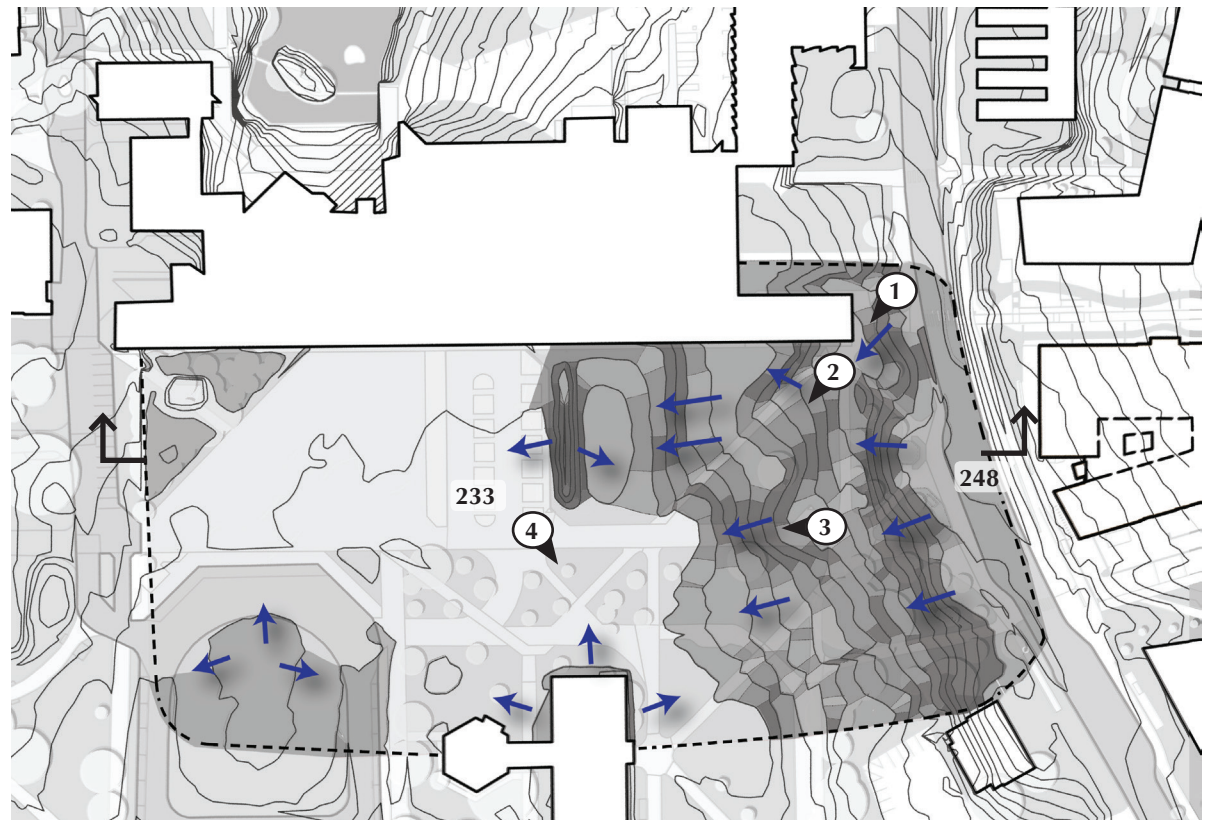




## SLOPES AND DRAINAGE

The site is mostly flat with some topographic changes along its eastern border. There is about a 15' grade change from North Pleasant Street to the FAC plaza, which is the low point. The site has a band of 8-15% slopes just west of North Pleasant St., but more than half of the site is quite flat. Stormwater drains westward from North Pleasant Street toward the FAC Plaza. Currently there is only one major path that has about 5% slope. The other main path goes directly up the west to east slope.

Currently, puddling is occurring at the base of the slope. Roof run off from FAC adds to surficial drainage, causing erosion along the sides of the major diagonal path. Water also pools on the north of the ISOM, where the ISOM addition will be located. Puddling especially occurs at the first flat segments along the central path.

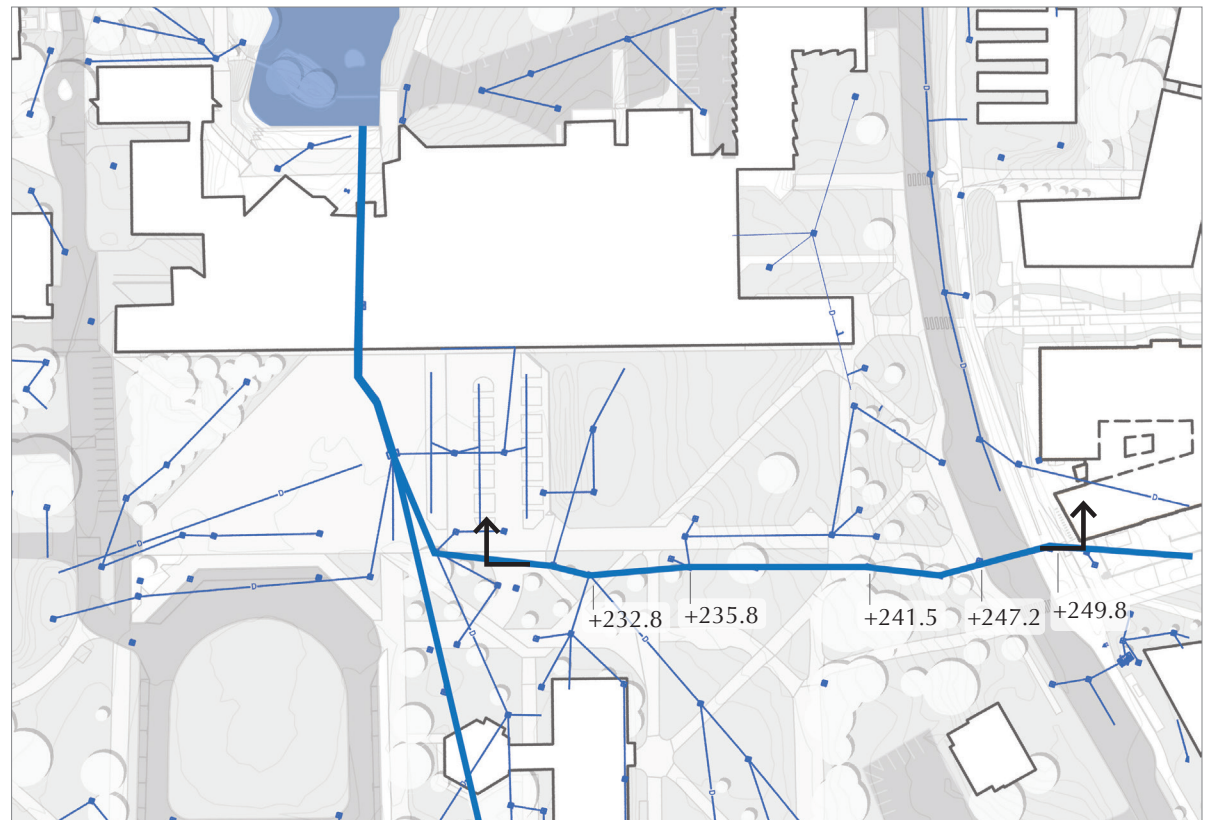
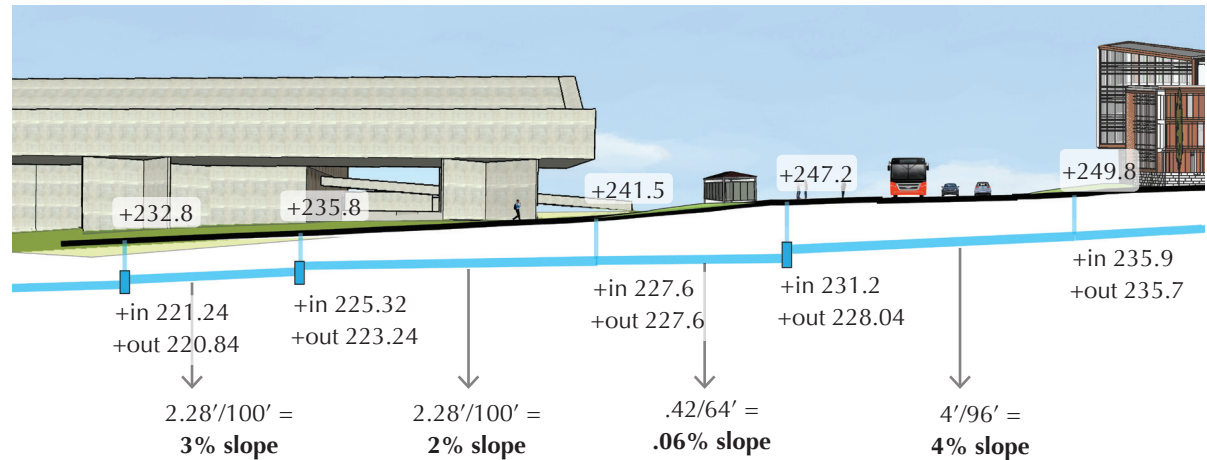


## STORMWATER INFRASTRUCTURE

Underneath the site, there is a large network of grey stormwater infrastructure. A 36" pipe runs along the south side of the main path between Haigis Mall and North Pleasant Street, carrying stormwater runoff from a network of pipes east of North Pleasant Street (see figure on p. 43). Culverted Tan Brook which runs along the west side of ISOM, converges with the 36" pipe in front of the FAC and become a 42" pipe. The combined pipe then drops under the FAC and discharges into the Campus Pond. There are also several surficial storm drains within the focus area.

Campus GIS data was explored in order to assess the potential volume of stormwater the pipe could carry. In order to find the slope of the pipes, the invert elevations were identified, and the length of the pipes measured (see figure top right). However, some of the slopes of the pipes were incredibly steep for the pipe's manning roughness ("sewer with manholes, inlet, etc., straight" = .017). The average slope of the pipe, which should be able .05% or less, is about an average of 2%. Therefore, running at two-thirds capacity (66%), the pipe supposedly carries 1.57 cubic m/s or 55.44 cubic feet per second.

This indicates that either the GIS data is incorrect (which was recieved from Tighe & Bonde 2016), or this pipe is severely strained and likely needs to be replaced. Since this pipe may likely need to be replaced, the opportunity to integrate green infrastructure practices and possibly daylight this massive urban stream should be explored.





The storm sewershed collected into the site's 36" pipe is roughly 48 acres. While there is potential to treat and slow some of the stormwater passing through the focus area, this 2.3 acre site alone can not and should not treat all of this stormwater. Stormwater coming from off site should be treated as close to its source as possible. It is important that green infrastructure practices be integrated higher up in the sub-watershed.

In 2015, a group of MLA students (Meilan Chen, Zhuoya Deng, Joe LaRico and Bien Liu) proposed a conceptual campus wide green infrastructure stormwater management plan, along with a few site specific recommendations. The graphic (bottom left)

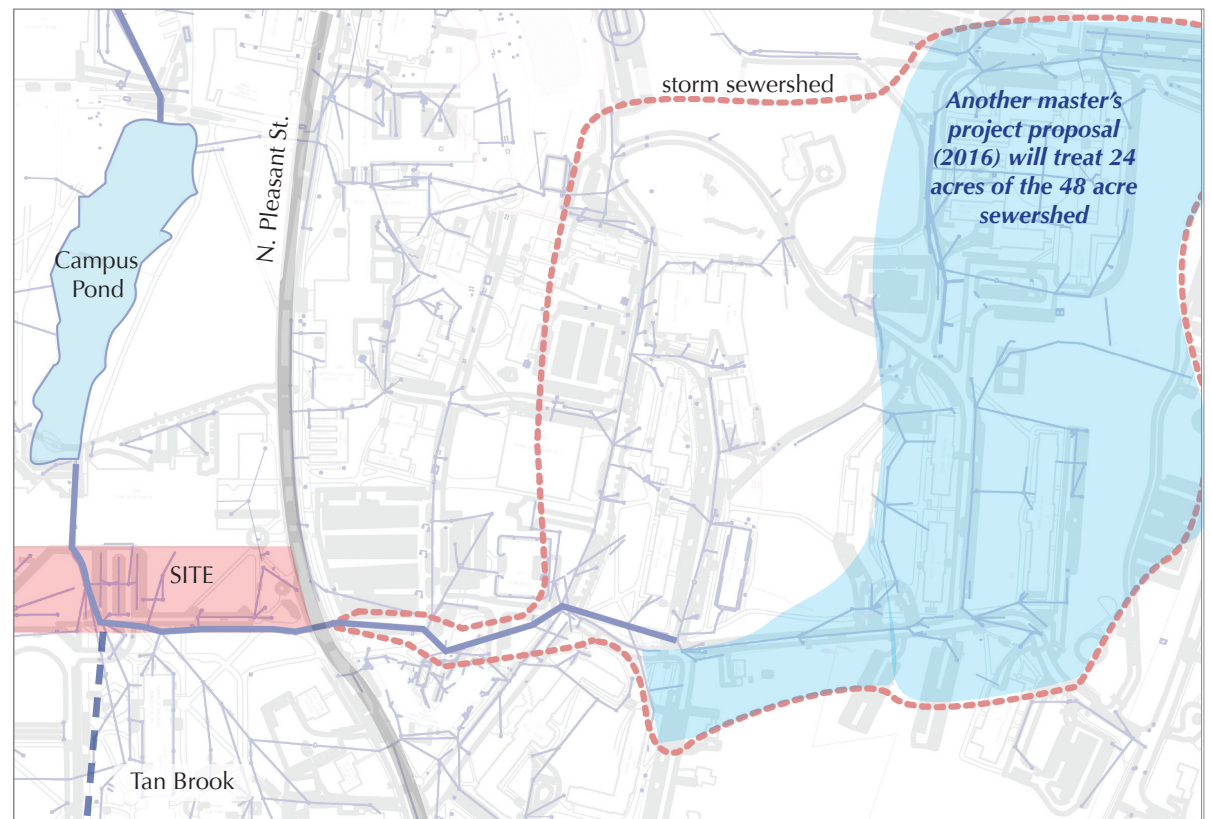


Meilan Chen, Zhuoya Deng, Joseph LaRico, and Bin Liu; GSI campus plan proposal 2015

below shows the long-term vision for campus. The goal for the campus is to implement many small green infrastructure projects to gradually decrease the volume of stormwater that is concentrated into pipes, like the one that passes through the project site.

Currently, there is another group of MLA students (Jing Wang, Yue Li, Yi Yang, and Yu Yu) working on a green infrastructure plan that will treat about half of the first flush of stormwater from the 48 acre site (24 acres). In order to capture the first flush (1") of a 24 acre area, (24 acres / 12 inches = 2 acre feet). There is potential for the landscape in front of the FAC, in addition to the integration of some green infrastructure higher up in the storm sewershed, to manage and filter most of

the first flush from the 24 acre storm sewershed. The redundant integration of diverse green infrastructure systems that manage stormwater closer to its source will lessen the need to have to manage such large quantities of stormwater from any one pipe.

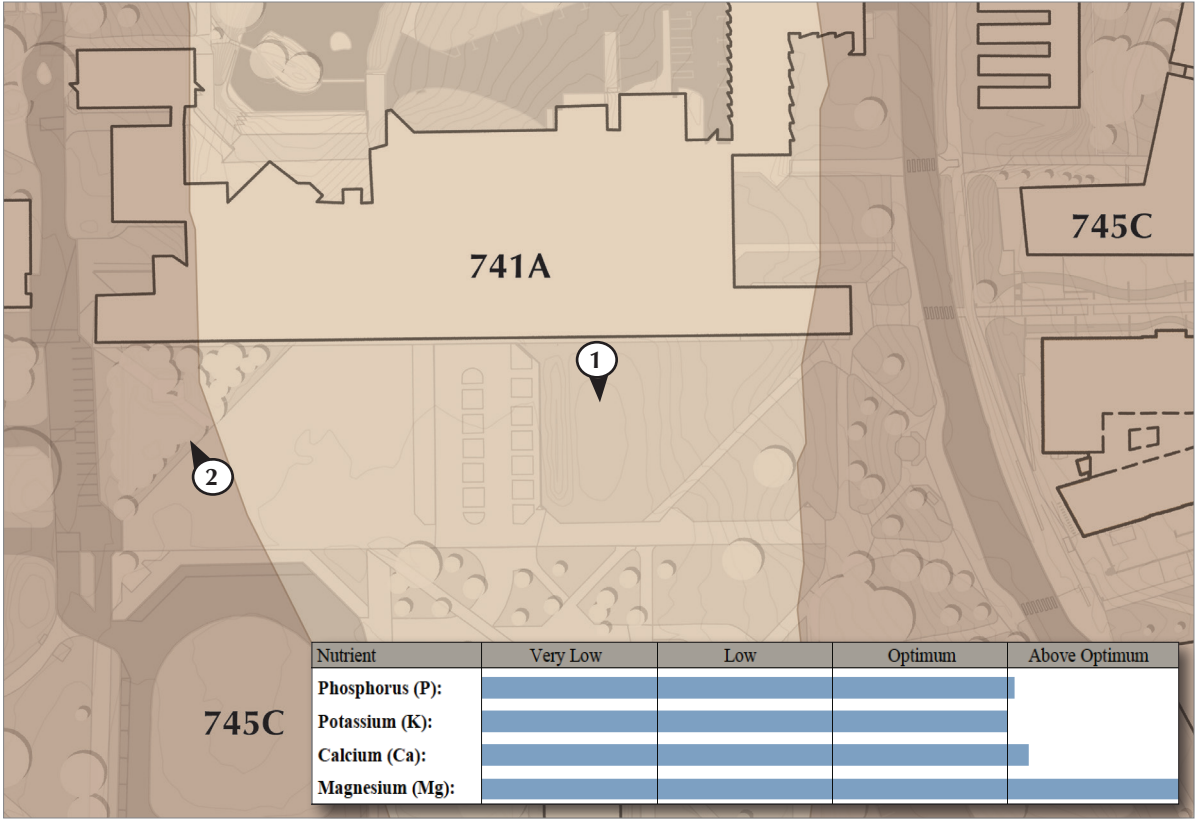
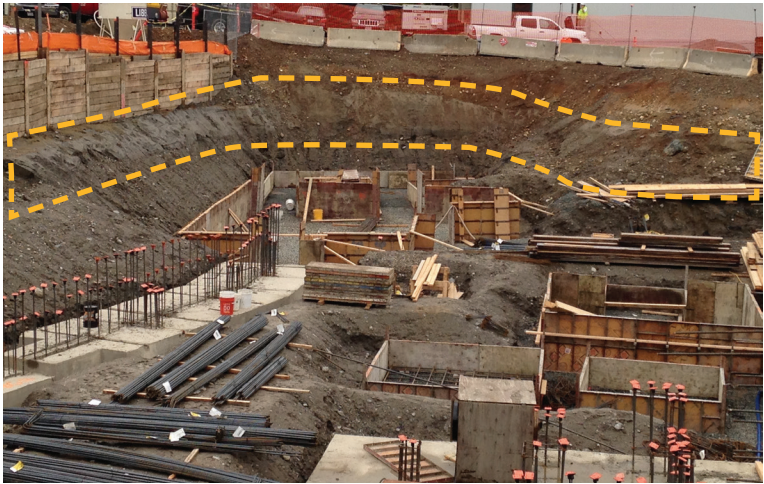


# SOILS

The Massachusetts Soil Survey indicates that the site is comprised of sandy loam. The flatter part of the site is Amostown-Windsor silty substratum with 0-3% slopes (741A). The soil type is fine sandy loam, and it is moderately well-drained. The Soil Survey indicates that the water table is 18-36". However, on-site observation indicates that the water table is at least 36" deep, as the existing rain garden in the FAC plaza sits about 2-3' below grade, and standing water is not present (see photo top left). The upper part of the site is comprised by Hinckley-Merrimac-Urban land complex with 3-15% slopes (745C). The soil type is loamy sand it is excessively well-drained, with 80+" to the watertable.

Excavation for the DB exposed the shoreline of historic Glacial Lake Hitchcock (see photo top right). Layers of densely packed, fine silty sediment due to the presence of Glacial Hitchcock may be present in the site. This soil may block infiltration and need to be excavated in some areas to allow infiltration.

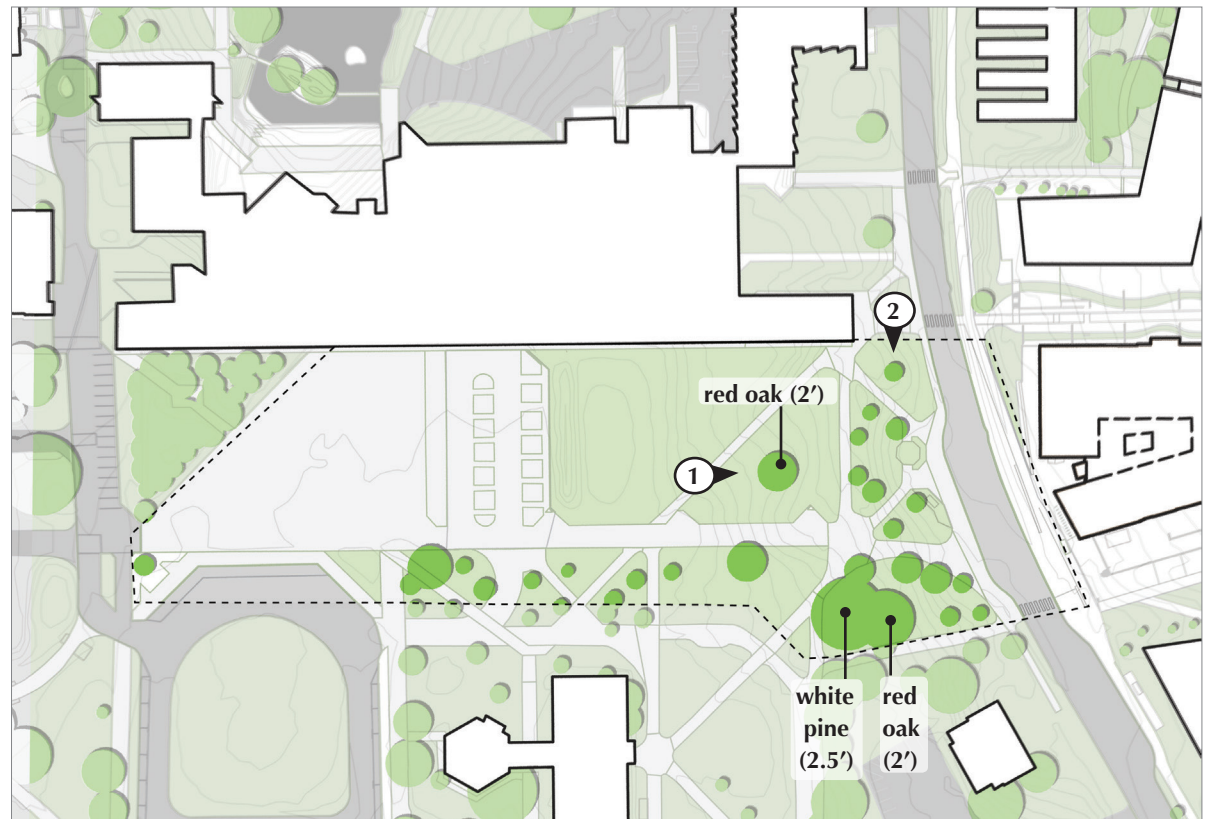
Soil samples were taken the site. Test results showed high levels of magnesium at 213 ppm (optimum range 50-100), and above optimum levels of phosphorus and calcium. All other results were normal. High magnesium is likely due to liming.



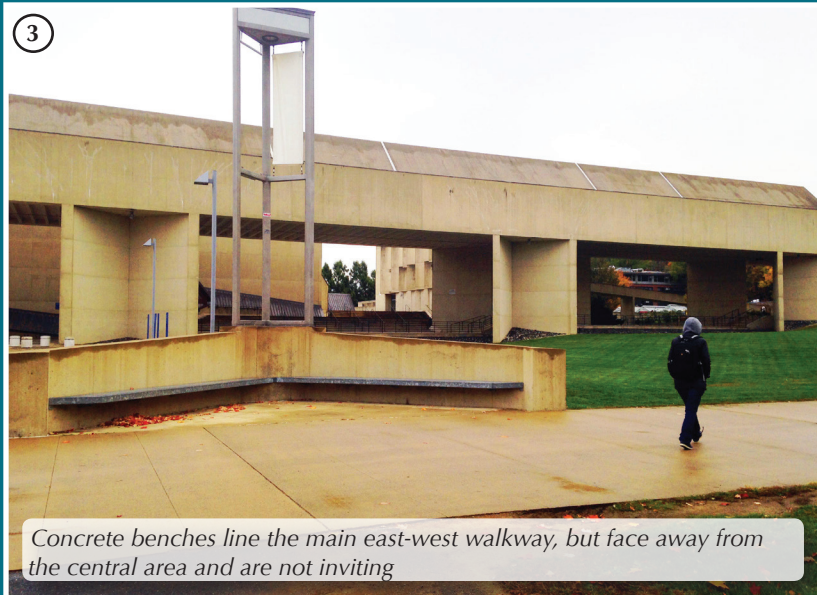


## VEGETATION

The site has three trees that are over 1.5' DBH (diameter at breast height): two red oaks and one white pine. The small trees on the eastern slope are a mix of Japanese flowering cherry and American elm. The small trees north of ISOM are a mix of river birch and red maple. The trees north of the ISOM will be removed for the ISOM addition, and it may be possible to re-purpose and transplant some of those trees for the proposed design. The preservation of existing trees should be explored where possible.







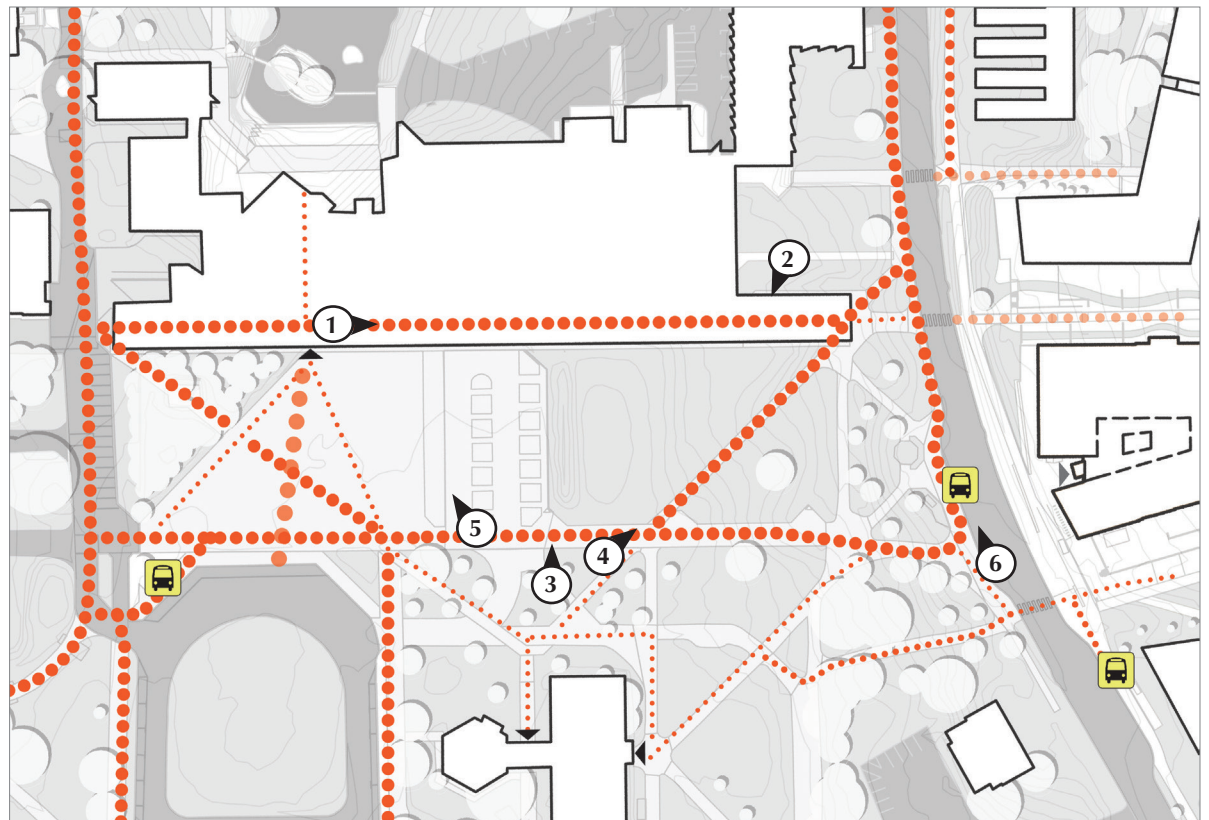
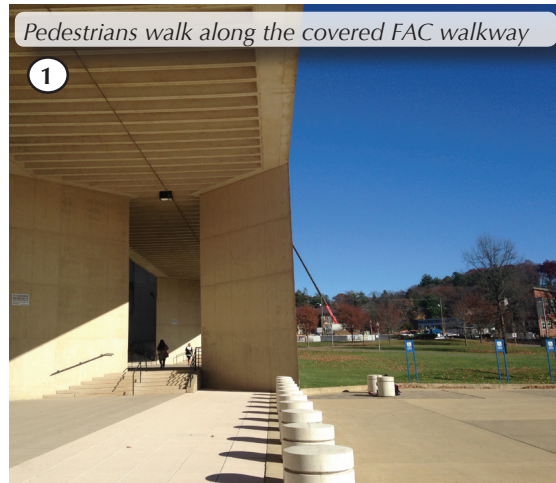


## PEDESTRIAN CIRCULATION

The project site is located near several major pedestrian hubs. The FAC is a major modernist building with a significant pedestrian arcade that runs along its southern face (photo 1). This characteristically strong corridor carries a significant number of pedestrians each day. The FAC hosts public events frequently, and therefore the Haigis Mall drop-off is an important access point for school field trip bus stops and visitors. A main path runs north of the ISOM east and west, and another diagonal path runs northeast and southwest. Pedestrian activity is also prominent along both sides of Haigis Mall. Pedestrian connections to the bus stops are crucial to the flow of circulation.

Haigis Mall is a major hub for pedestrians arriving and leaving via PVRTA and Peter Pan buses which travel regionally. The two bus stops along North Pleasant Street serve UMass students heavily during business hours, but bus routes connecting North Amherst to downtown Amherst and South Amherst also transport local residents year round. Many students use bikes on campus and take bikes on and off the buses that arrive at Haigis Mall.

Pedestrian desire lines cut across the central grass quad as view lines to destinations become visible in conjunction with no path edge definition. There are many small minor paths directly west of North Pleasant Street that are not frequently used and could potentially be eliminated. The network of paths lacks coherence. The paths do not flow from the crosswalks. There are currently few pedestrian amenities that invite pedestrian to sit and stay. Existing concrete benches face away from the campus quad and are not inviting. Connections to the existing crosswalks and a more coherent, simplified, accessible network of pedestrian path should be explored.





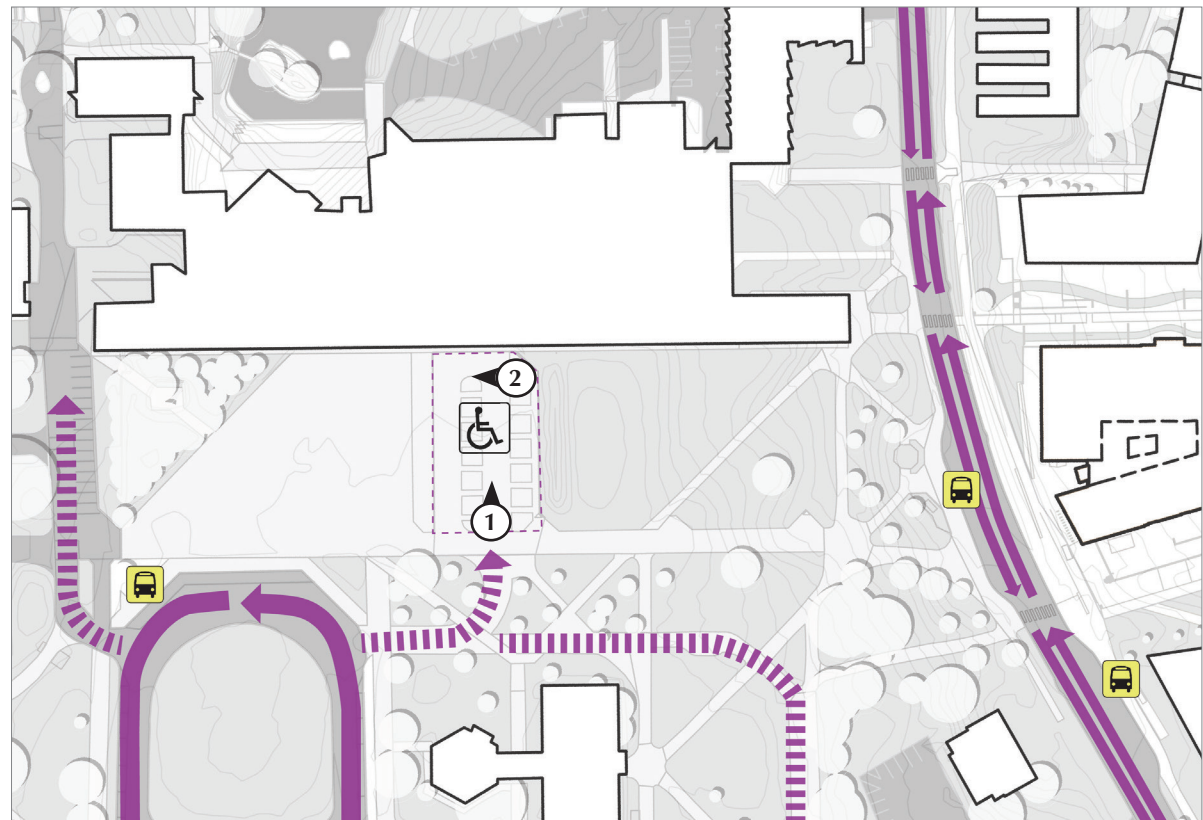
## VEHICULAR CIRCULATION

Haigis Mall is a major, one-day drop off loop for vehicles; it is the “Gateway” for arriving on campus. Parents and friends use the loop to pick up or drop off students usually in the morning or around the end of the work day. PVTA buses heavily use the drop off loop during these hours as well.

There are a couple important service roads that connect to Haigis Mall. One service road extends around the west side of the FAC. One extends around the east side of ISOM. The latter service road will be re-located due to the proposed addition on the north side of the ISOM. One short service road north of the ISOM provides ADA access to FAC. It is also occasionally used for catering service and fire access. The necessary number of FAC parking spaces is unknown to UMass Campus Planning. The handicap requirements for the FAC are complicated by the public events the FAC hosts. However, observations noted throughout hundreds of site visits during both regular use and during special events confirm that rarely more than three ADA parking spaces are ever used at a time.

North Pleasant Street is a heavily 2-lane trafficked public ROW with no bike lanes. During class change, the vehicular traffic gets backed up, leaving drivers idling for long periods of time as they wait for a break in pedestrian traffic. The project site is visible to traffic along North Pleasant Street. Both UMass faculty and students and local residents use North Pleasant Street. North Pleasant Street connects North, downtown, and South Amherst. The bus routes along North Pleasant St are used frequently by locals.

The view from a car along North Pleasant Street and from Haigis Mall should be considered in the proposed landscape design. Some handicap spaces will need to be preserved in front of the FAC.



# CONCLUSION

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## SUMMARY ANALYSIS

In summary, the opportunities and constraints presented in the assessment of this project site on UMass Amherst campus inform design direction. The location of campus within its watershed and ecological context indicate the importance of minimizing impervious surface and restoring biodiversity of native plant communities. The cultural context of the site's specific location within campus presents an important opportunity for the landscape to be seen and used by both UMass affiliates as well as the public. The addition of the Design Building and the ISOM will drastically change the shape and use of the site. Across the street from the new Design Building, this landscape has the potential to reflect UMass's commitment to and investment in creating a sustainable campus with a resilient green stormwater infrastructure display. The strained grey infrastructure network running underneath the site could be exposed and showcase green stormwater infrastructure. Polluted stormwater runoff could be remediated on site using best-management practices. Well-draining soils, but a potentially high water table indicate the importance of having subsurface drainage and overflow systems that connect to the existing grey infrastructure system. Puddling and erosion show the surficial need to improving drainage and redefining path edges for pedestrians. The site is located within a major transportation hub, yet the path system is incoherent and some major paths run up steep slopes. Three significant trees are located on this site, yet the species are not of special ecological importance. The FAC plaza is entirely paved, half of which is used for handicap parking, though not all of it is utilized and is not necessary. There are important service roads that will need to be maintained or re-routed for public safety. There is potential to reduce impervious surface, restore a coherent pedestrian pathway system, and showcase sustainable landscape design, while respecting the needs of campus.

## OPPORTUNITIES FOR SUSTAINABILITY

There is potential to daylight the grey stormwater infrastructure and send the polluted stormwater through a series of best-management practices. These BMPs could infiltrate and filter pollutants while providing shade and possibly reducing building energy use. The location and use of the site is prime for educational opportunities and possibly signage. The GSI should be planned and designed in a way that improves the pedestrian network and offers beautiful places for site users to site, stay, and recreate. Three significant trees should be protected where possible to maximize ecosystem services. The unnecessarily paved parts of the FAC plaza could be re-vegetated. The FAC is a large, iconic building and the landscape design should reflect the scale of the building's presence on campus while also reflecting the shapes of other surrounding buildings.

The Sustainable SITES Initiative guidelines provide important pre-design and planning site assessment steps that help designers and planners recognize the value or lack of integrity within the existing landscapes. The SITES design chapters draw on the site assessment inventory in order to preserve and enhance ecosystem functions; they will be used as guidelines for the following chapter. The proposed landscape design should incorporate opportunities for education and monitoring.





CHAPTER 5

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# PROPOSED DESIGN





# DESIGN

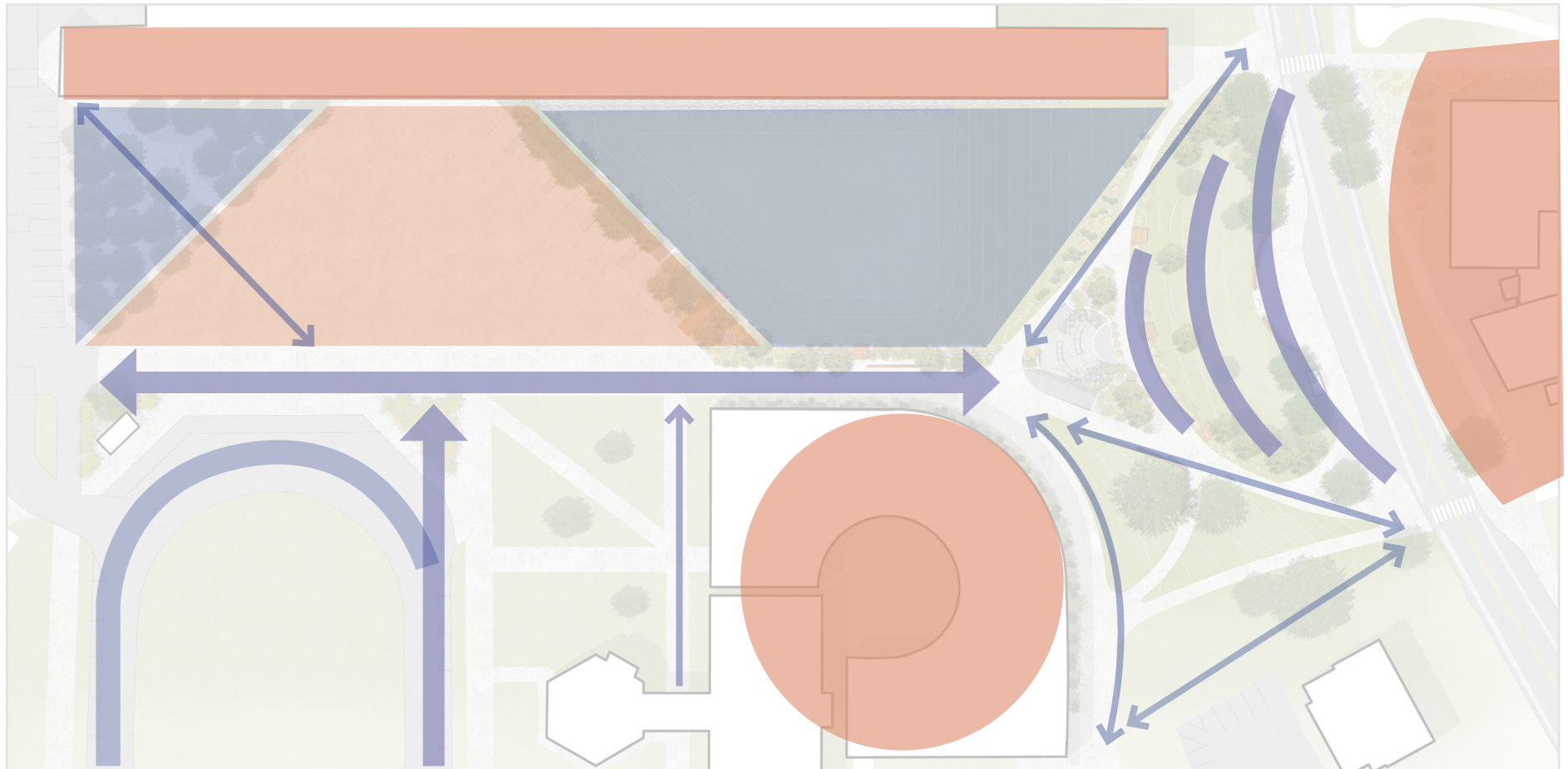
## OVERVIEW & GOALS

Central to the proposed design is the daylighted 36" stormwater pipe and three outdoor labs which provide educational opportunities to learn about stormwater on campus. Daylighted stormwater is sent through a series of bioretention cells and a sunken quad provides a disguised overflow basin. The design is based on the following SITES chapters: Water, Vegetation & Soils, Human Health and Well Being, Monitoring and Education, and Operations and Maintenance. The design reflects the shape, scale, and use of the

surrounding buildings. The intersection of rectangular, circular, and irregularly angular shapes comprising the surrounding buildings and existing landscape create a complex geometric base for the proposed design. In order to create a meaningful dialogue between the buildings and the proposed landscape, the existing shapes were used as inspiration to unite the landscape in between.

The goal of this site is create a Sustainable SITES Initiative demonstration project that maximizes ecosystem service opportunities through: creating a

culturally importance space with improved views and circulation, artfully displaying sustainable stormwater management, and integrating green stormwater infrastructure that is easily monitored and utilized as an education platform. The goal of the proposed GSI is to: improve water quality and reduce the urban heat island effect, provide record/evidence for future green infrastructure installation, and help UMass meet some of its MS4 objectives.





*Haigis Mall drop off point  
& Gateway to campus  
becomes more striking*

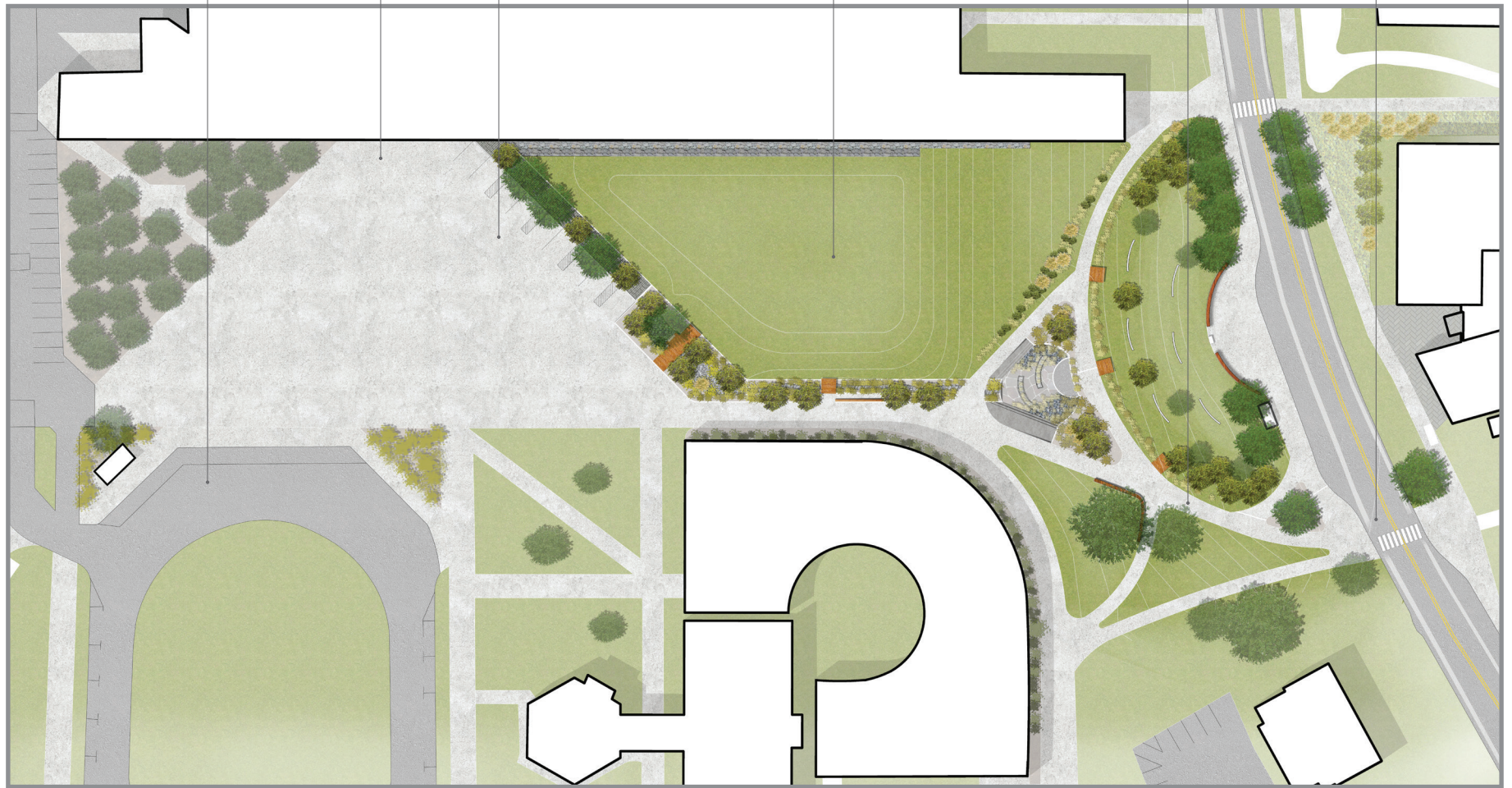
*FAC Entrance is  
reframed with  
reflected geometry*

*Less paving and more trees in  
the FAC Plaza create a more  
human scale experience*

*The sunken quad creates a place  
to recreate, stormwater overflow,  
and an outdoor classroom*

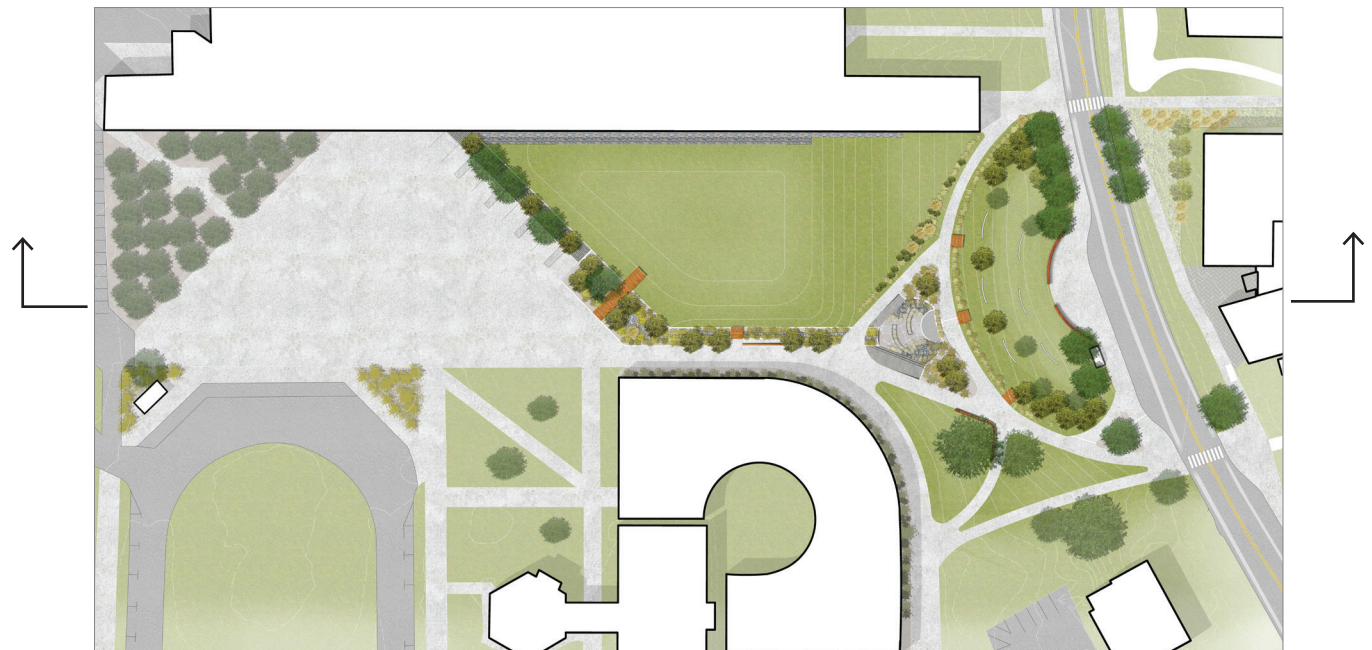
*A simplified path system  
creates more legibility  
between bus stops*

*Existing crosswalks connect  
to proposed universally  
accessible pathways*





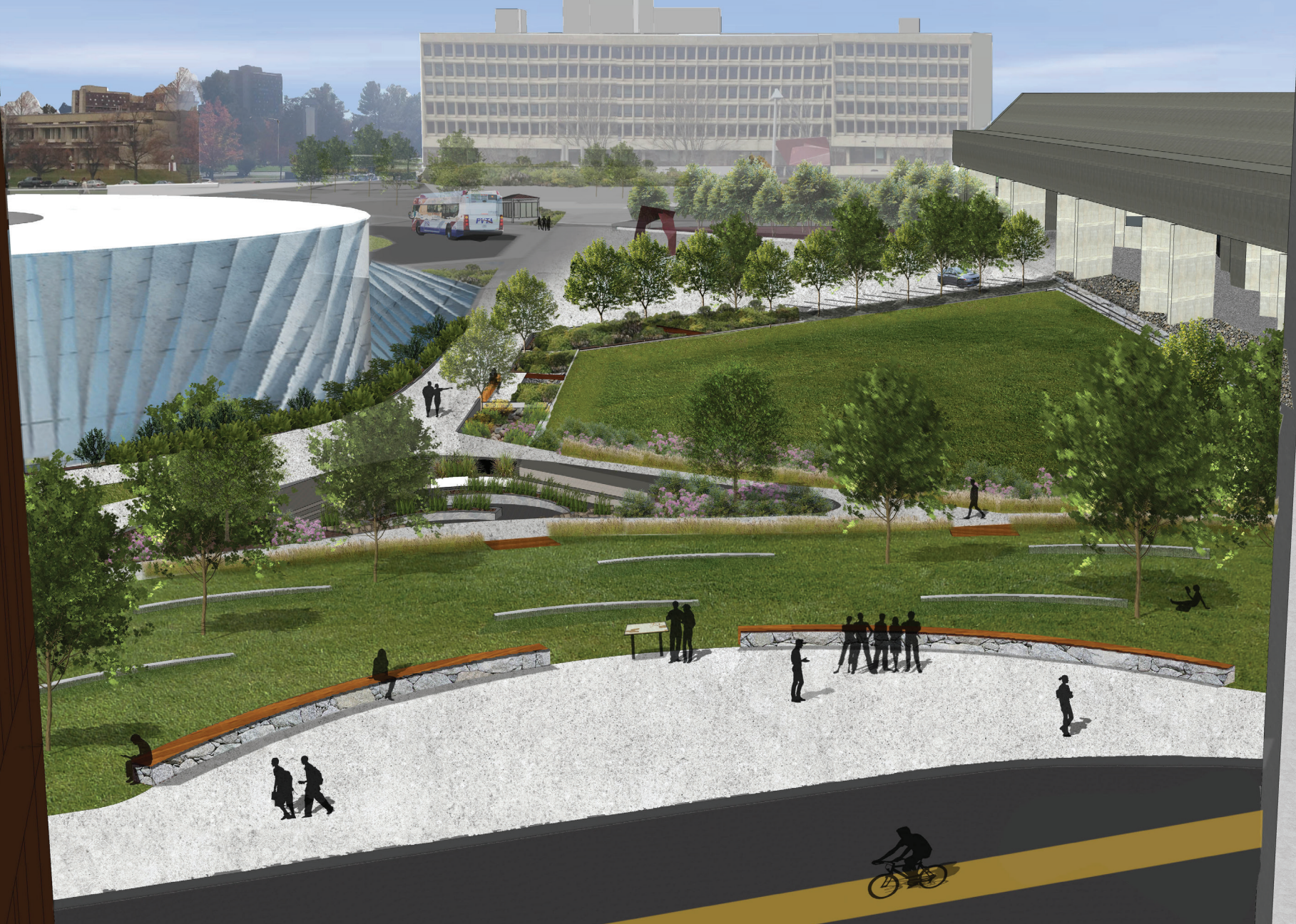
The section above shows the that a central feature of this landscape design plan is the 36" daylighted pipe that runs under the existing path. The entrance to the FAC is framed with a vegetative edge that reflects the same 45 degree angle as the existing rain garden across the plaza. The entrance to the FAC becomes more legible and prominent. .











*View from the Design Building's Green Roof*



## SOILS & VEGETATION

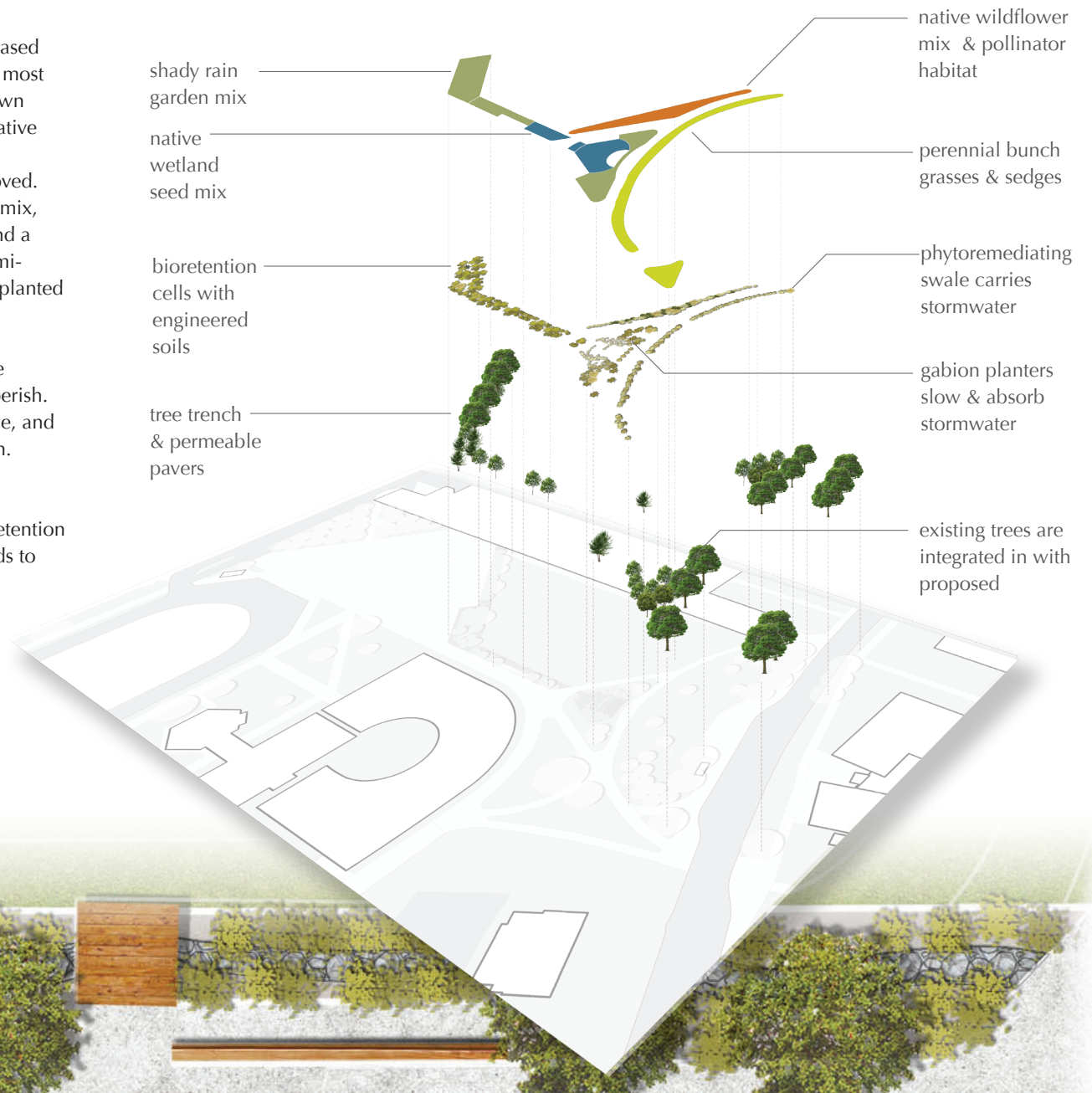
A large portion of the proposed planting strategy is based on selecting appropriate seed mixes, then letting the most resilient plants self-select for each planting area (shown color coded in the top right layer). When allowing native plants to establish, the cells should be monitored for invasive species, which should be immediately removed. The planting areas include a shady rain garden seed mix, native wildflower and pollinator habitat seed mix, and a native water-loving seed mix. The swale along the semi-circular, which carries stormwater from the street, is planted with perennial, phytoremediating bunch grasses.

Over time, the plants that are the most tolerant of the conditions will thrive, leaving those less tolerant to perish. In this way, the plants requiring the least maintenance, and contributing the most biomass to the soil will flourish.

Bioengineered soils, which help with drainage and vegetative productivity, will be necessary in the bioretention cells. Biomass from mowing should be left in the beds to build biomass. Compost tea should be administered annually to help balance pH.

Two of the significant existing trees are kept, and seven of the smaller existing trees are re-purposed.

*Sustainable Sites prerequisites & credits met:*  
P4.1, P4.2, P4.3, C4.4, C4.6, C4.7, C4.8



## SHADY RAIN GARDEN



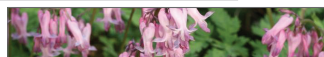
*Chelone glabra*



*Iris versicolor*



*Aruncus dioicus*



*Dicentra eximia*



*Onoclea sensibilis*



*Aquilegia canadensis*



*Aster novae-angliae*



*Asclepias incarnata*



*Helianthus angustifolius*



*Aquilegia canadensis*

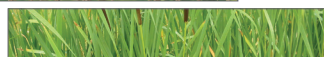
## NATIVE WETLAND SEED MIX



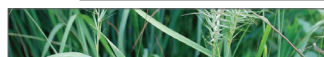
*Scirpus atrovirens*



*Glyceria striata*



*Typha latifolia*



*Carex hystericina*



*Rudbeckia laciniata*



*Aster novae-angliae*



*Onoclea sensibilis*

## POLLINATOR HABITAT SEED MIX



*Asclepias tuberosa*



*Monarda didyma*



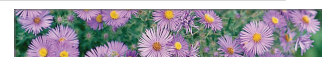
*Echinacea purpurea*



*Eutrochium purpureum*



*Aquilegia canadensis*



*Aster novae-angliae*



*Asclepias syriaca*

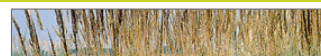


*Zizia aurea*

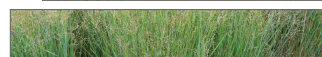


*Rudbeckia hirta*

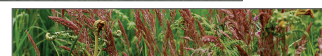
## PERENNIAL GRASSES & SEDGES



*Sorghastrum nutans*



*Panicum virgatum*



*Festuca rubra*



*Betula negra*



*Populus deltoides*



*Acer rubra*



*Ulmus americana*

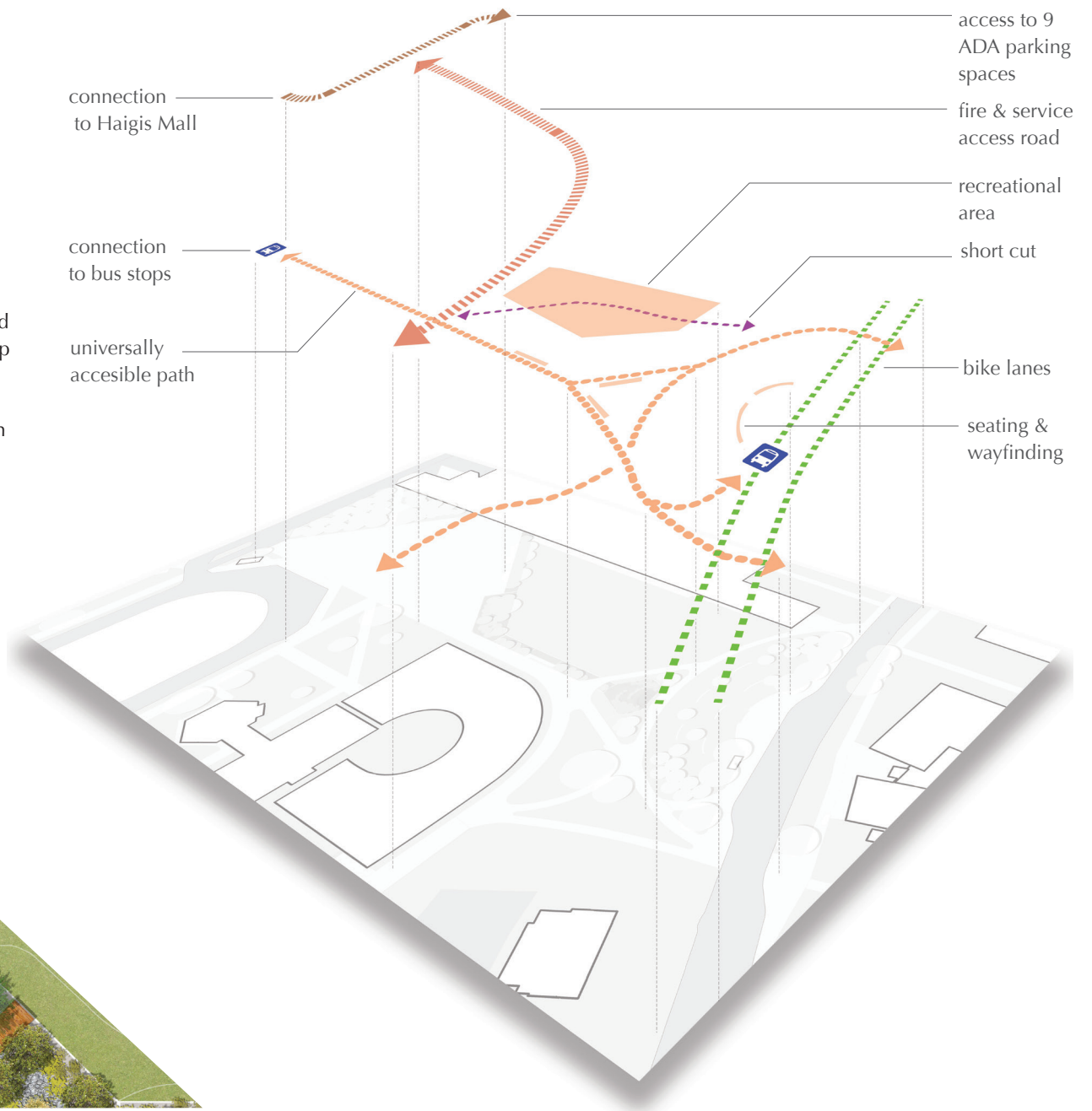


## HUMAN HEALTH & WELL-BEING

The proposed circulation includes two major universally accessible walkways, re-routing and simplifying the existing steep pathways. New pedestrian seating areas, signage, and a recreational quad allows for mental restoration, educational opportunities, physical activity, and social connection.

A fire service access road wraps around the proposed ISOM addition, ensuring safety and access. Handicap parking access is rerouted away from pedestrian traffic in front of the ISOM. Nine handicap parking spots adjacent to a permeable paver lined tree trench allows access to the FAC while incorporating the opportunity to keep cars cool.

*\*Sustainable Sites prerequisites & credits met: P4.1, P4.2, P4.3, C4.4, C4.6, C4.7, C4.8*

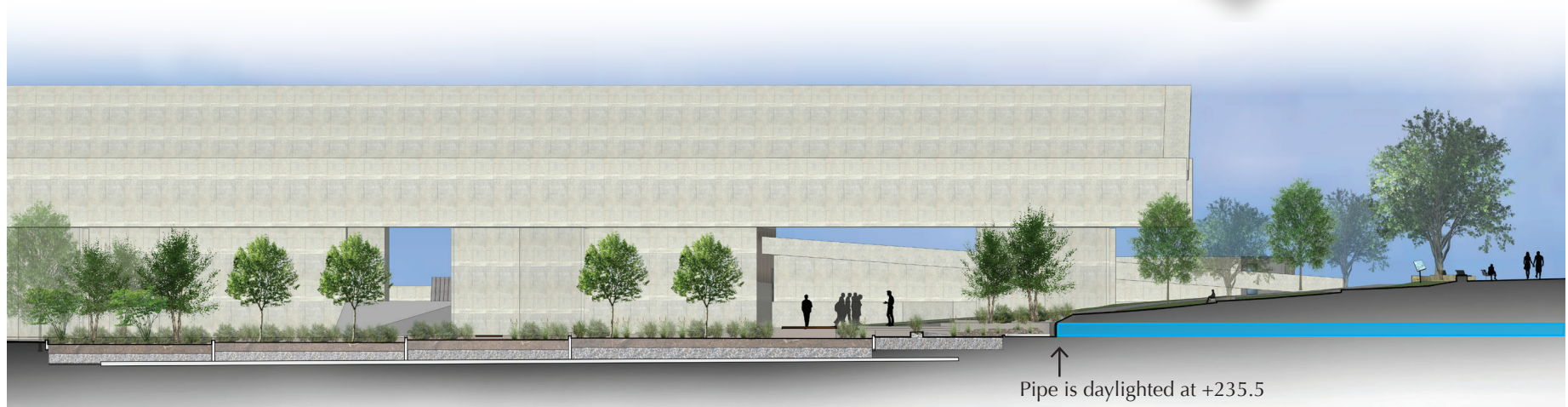
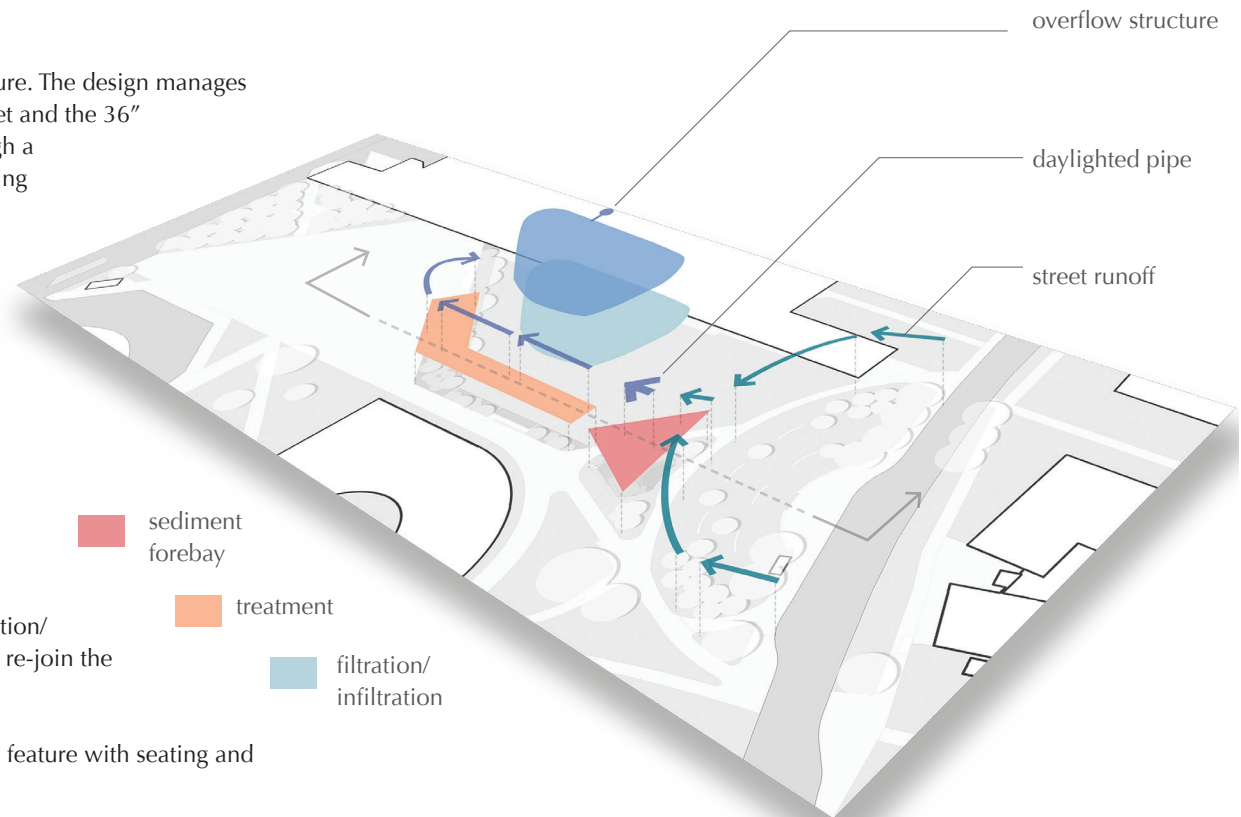


## WATER

The hydrologic system is the proposed design's central feature. The design manages two sources of stormwater: runoff from North Pleasant Street and the 36" pipe below. Both sources are combined and then go through a remediating process, which also irrigates vegetation, reducing water use for landscaping and manages precipitation beyond baseline. Impermeability is decreased by 19%.

The first source is intercepted catch basins along North Pleasant Street. Stormwater is redirected into runnels through the sidewalks, and then into swales which run along the semi-circular path. The swales have phytoremediating grasses which filter and breakdown phosphorus, nitrogen, and some hydrocarbons. Overflow from the swales meet in the middle and flow through another runnel into the sediment forebay for the second hydrologic system. The 36" pipe running under the site is daylighted, and sent through three systems with separate functions: a sediment forebay, treatment cells, and a infiltration/ filtration area. An overflow structure allows excess water to re-join the existing grey infrastructure system.

The stormwater system is displayed as an artful educational feature with seating and pedestrian amenities, while providing shade and beauty.



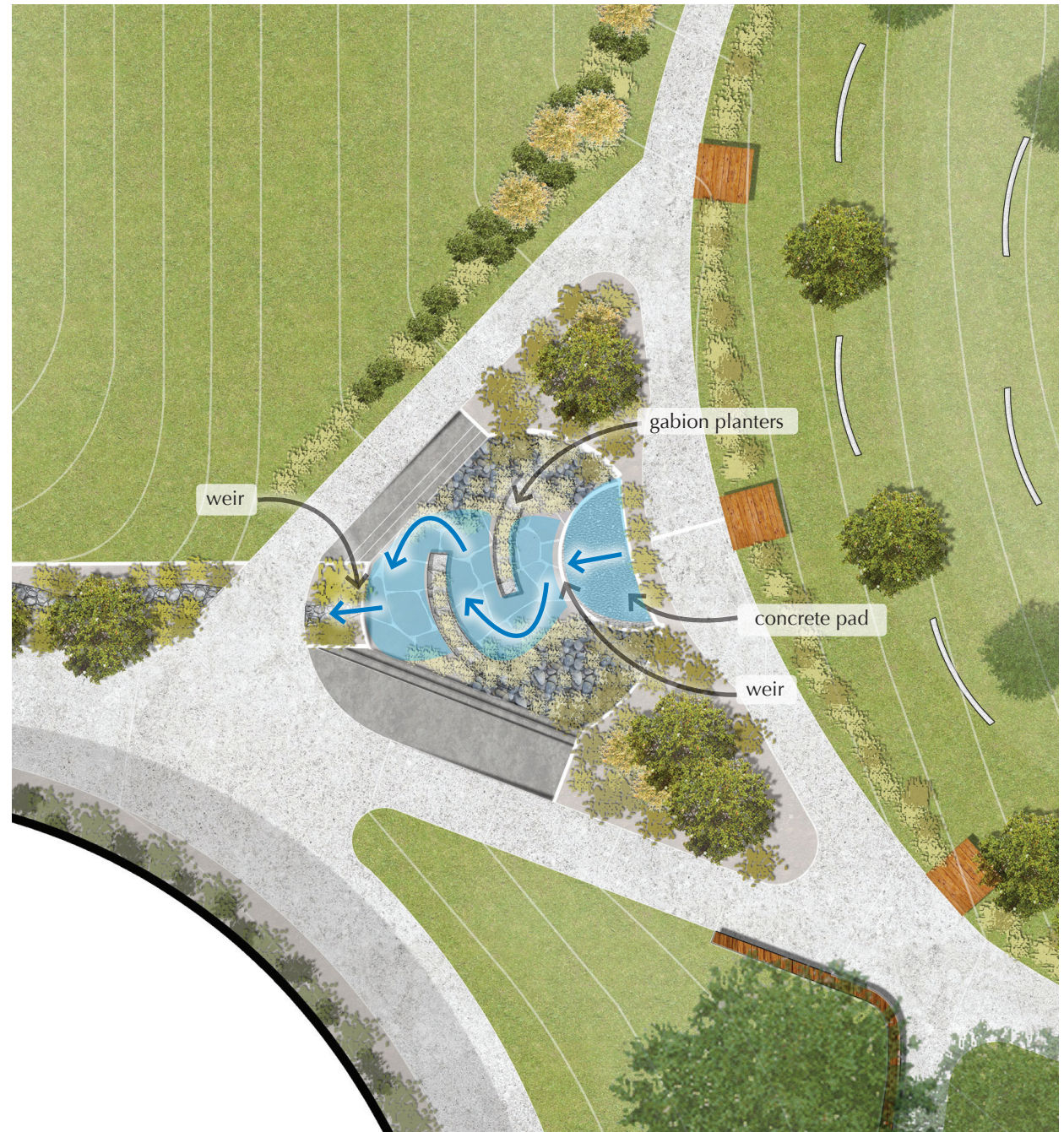
*\*Sustainable Sites prerequisites and credits met: P3.1, P3.2, C3.3, C3.4, C3.5*



## Sediment Forebay

The 36" pipe is daylighted into a sunken triangular area that serves as an outdoor classroom. After exiting the pipe, the water first enters into a concrete pad that is surrounded by a semi-circular 6" wall to capture initial debris and total suspended solids. The concrete pad allows for ease of maintenance, as it can be easily shoveled or hosed off. A weir in the wall directs water into a permeably paved area that slopes upwards, blending into stones mixed with water-loving grasses. Stormwater is slowed as it moves around the gabion planters, simultaneously waters the plants. Water has to rise 6" before spilling over another weir and traveling under the bridge and into the treatment cells.

<http://gardendrum.com/wp-content/uploads/2013/01/Design-Carl-Pickens-Ellerslie-NZ-2009-Gabions-filled-with-graywacke-pebbles.jpg>







*View from the top of the sediment forebay*



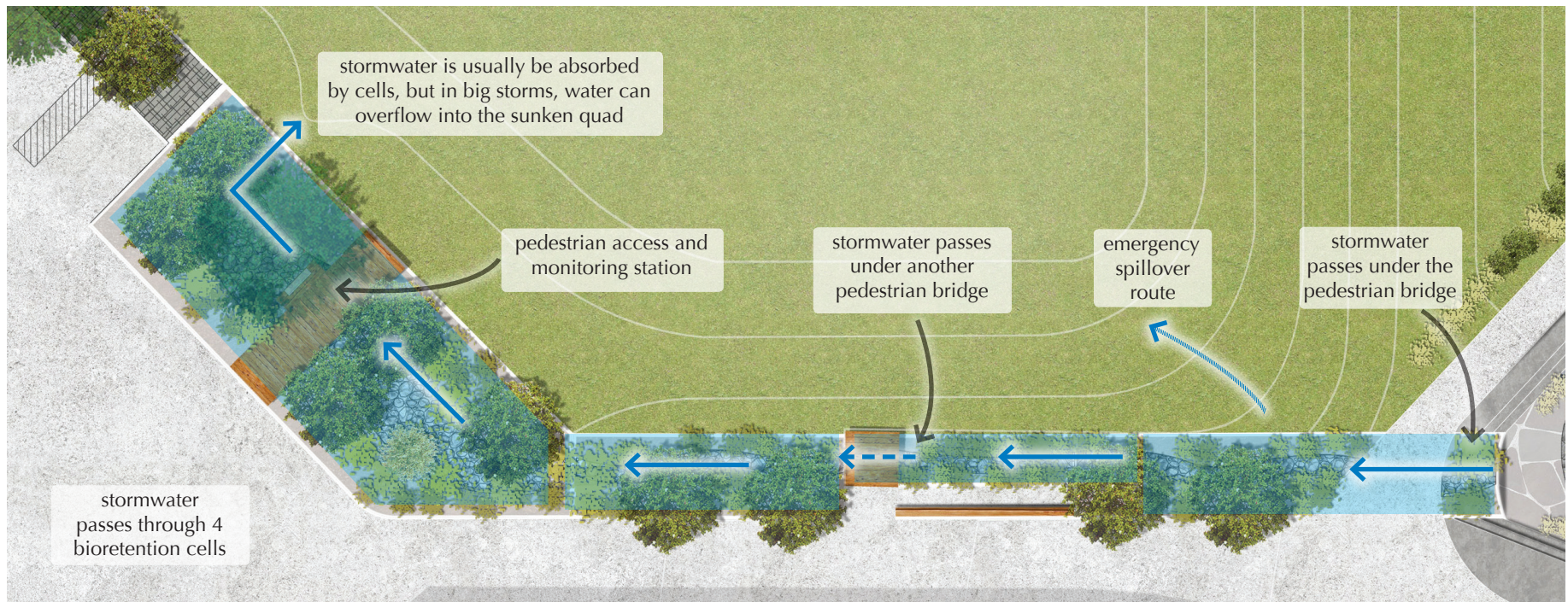
## Treatment

After the stormwater passes through the sediment forebay, it enters into the bioretention cells, which in a typical storm, treat all the stormwater. If stormwater discharges from the pipe more quickly than the system can handle, a weir in the first bioretention cell allows water to bypass the bioretention cells and overflow directly into the sunken quad.

The first cell, which will be wet more often than dry, hosts a native wetland seed mix. After passing through the first cell, water moves through three more cells, before overflowing into the sunken

quad if necessary. As the water interacts with engineered soils present in each of the bioretention cells, sediment, phosphorus, nitrogen, bacteria are removed and some hydrocarbons are broken down. The more prolific the plants, the more biomass is contributing to soil building, the healthier the soil, and the more pollutants are removed. Maintaining healthy soil through the annual application of compost tea will help keep microbial activity high, and with it, the degree of pollutants that are removed.

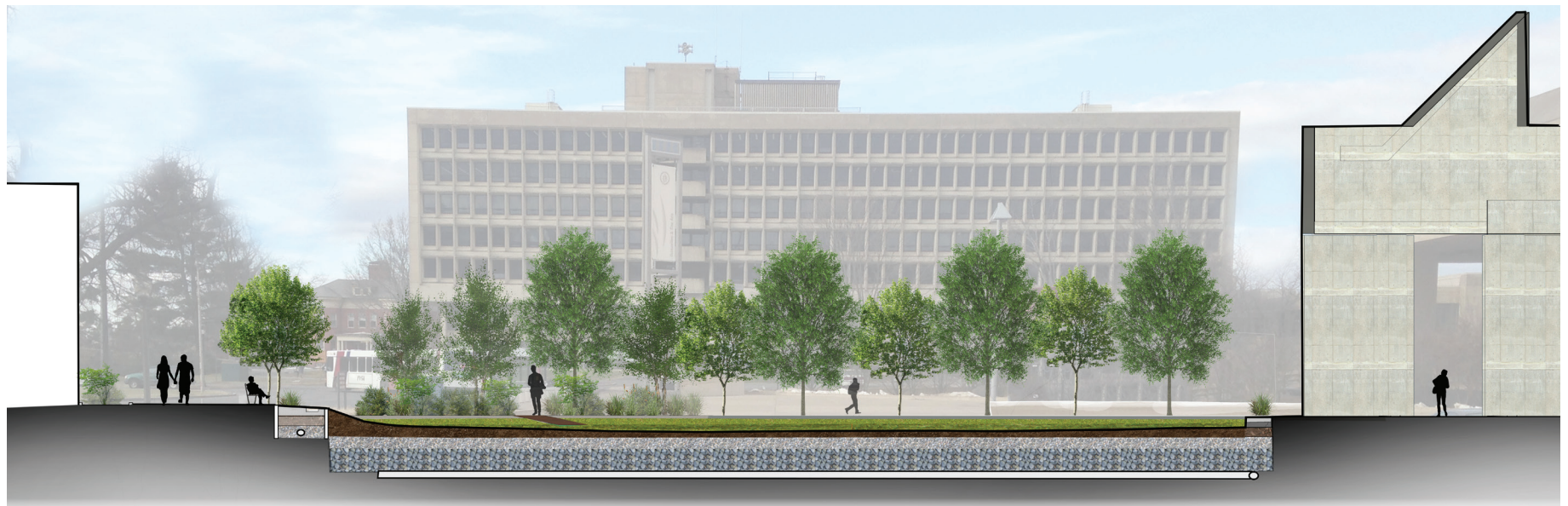
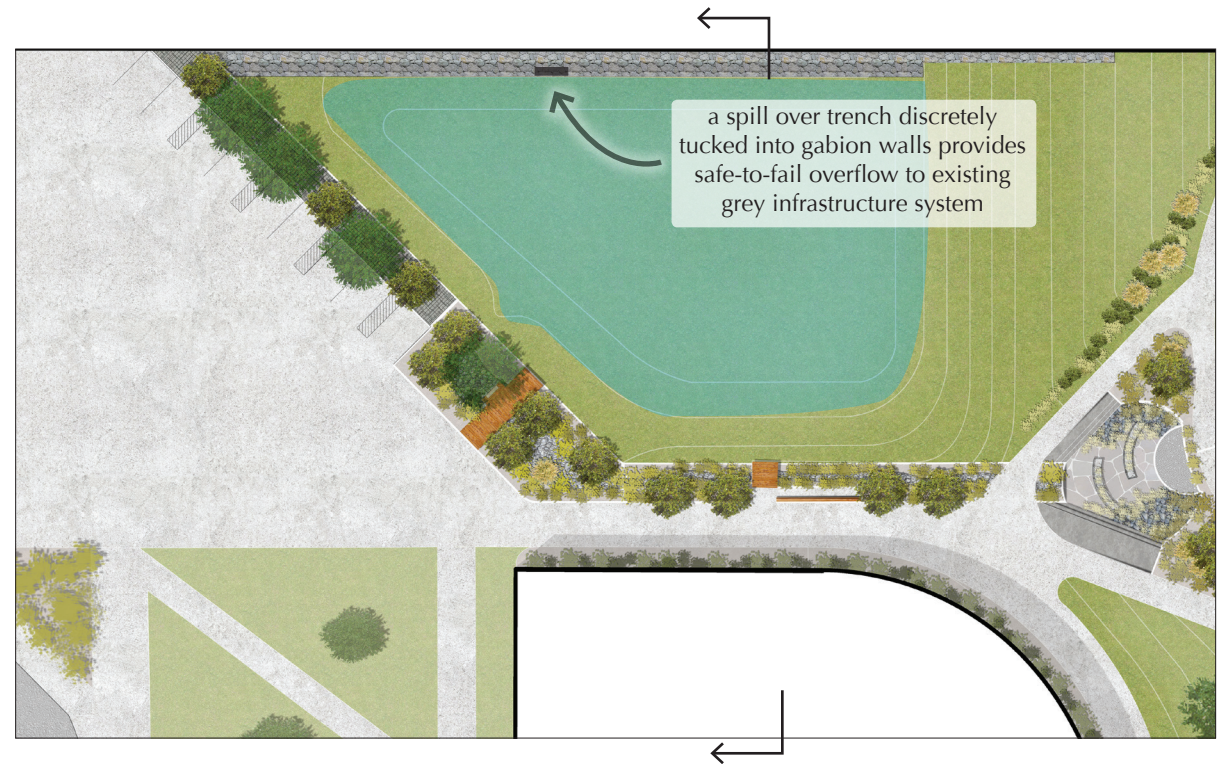
A bump out into the bioretention cells allows curious passersby to observe closely or just sit and relax in the shade.





## Infiltration & Filtration

Stormwater moves into the sunken quad where it infiltrates into the ground. Underneath the turf and a few inches of soil is a geotextile cloth. Below that lies two feet of 3/4" aggregate, then a perforated, geo-textile wrapped pipe network that collects excess water and allows it to drain into the existing grey infrastructure system. When water rises up to 1.5', and overflow trench drain built into the gabion wall on the north side of the sunken quad connects to the perforated pipe network, and ultimately the existing grey infrastructure system. Because the sunken quad will be dry most of the time, the quad is multifunctional in that it can also be used as a recreational area.





## MONITORING & EDUCATION

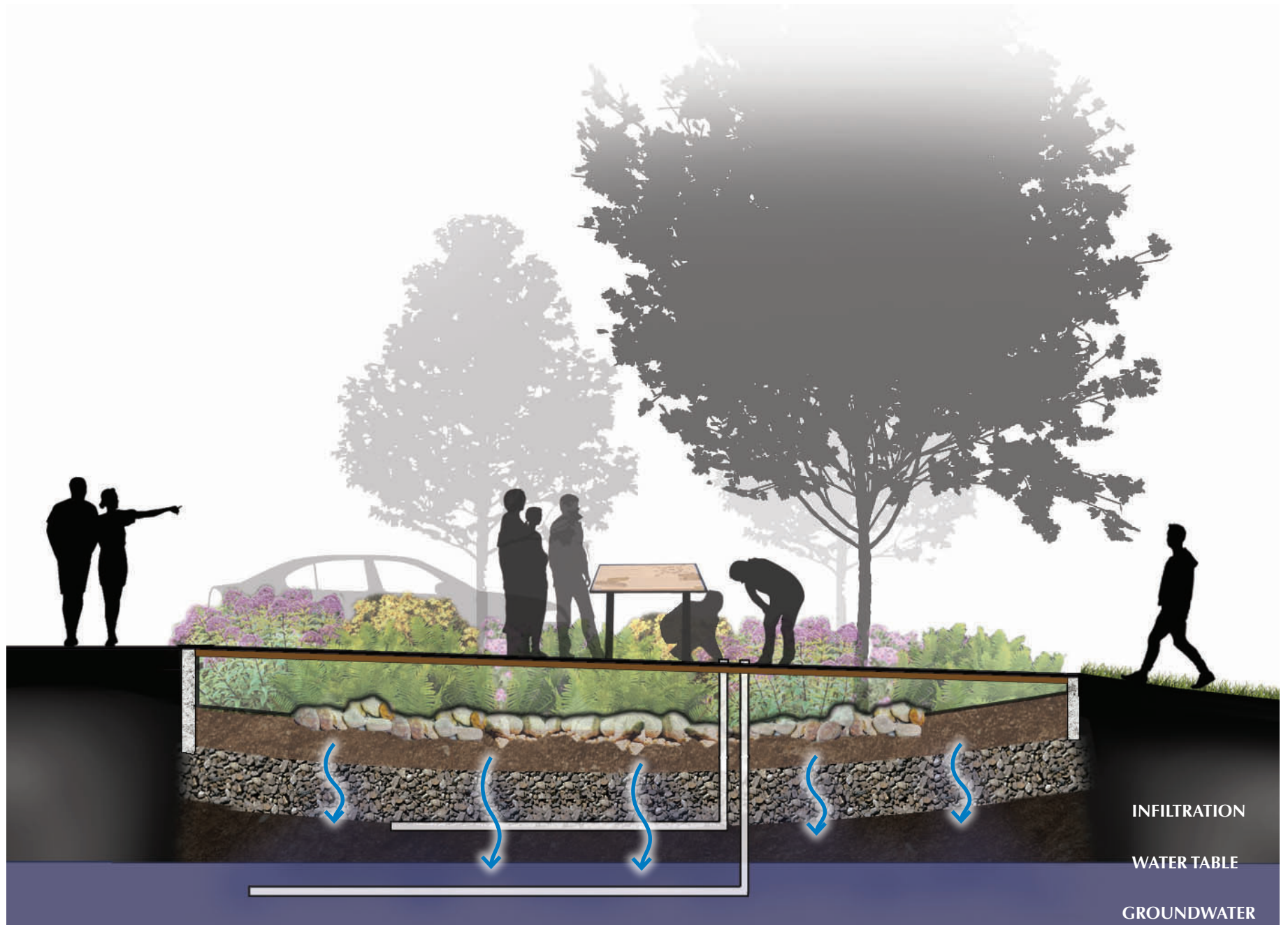
### Outdoor Classrooms

There are three outdoor educational platforms on the site (shown below as 1, 2, and 3). Classroom 1 is a prospect point with seating that overlooks the whole system. This could also be a location for using iTree, a USDA Forest Service software that can be used to measure the benefits of individual or groups of trees. Classroom 2: Water Quality Test Station 1 is a location where first flush water quality and sediment samples

can be taken. Classroom 3: Water Quality Test Station 2 is located at the boardwalk, where two monitoring wells measure the quality of water from two depths (see graphic on p.65). These classrooms can be used as platforms to teach classes regarding the destructive nature of the underground grey infrastructure system, as well as the potential for green infrastructure to provide a myriad of ecosystem ecosystem services. Students can take water, soil, and air quality samples at different locations throughout the site.









## ECOSYSTEM SERVICES & PERFORMANCE MONITORING

This multifunctional landscape has the potential to provide an array of ecosystem services. Using the Landscape Architecture Foundation's Landscape Performance Series Tools, there are currently a variety of ways of measuring these services.

The EPA's stormwater calculator is one of the tools featured on LAF's LPS tools website, which allows designers to predict what ecosystem services proposed landscapes may offer. This tool enables users to enter in square footage of specific best-management practices to give a rough approximation of ecosystem services provided by each structure. However, usage of the calculator is fairly limited in that it does not allow the user to curtail the best-management-practices in great detail. For this project, the BMP that most closely resembled the bioretention cells and the sunken quad in subsurface composition



<http://greenvalues.cnt.org/national/calculator.php>

was the "Bioswale" option. The calculator did not allow the option of adding perforated pipes or curbs, which allow water to fill up more than the "Bioswale" designation supposes. The calculator also allows the user to enter in the number of proposed trees, which in this case was 38. While there are a few different sizes of expected tree canopy, the calculator asks the user to enter only one value for the average canopy area, which in this case was 314 sqft, based on an

	Annual Benefits (\$)	Life Cycle Benefits (\$, NPV)
	Green Benefits	Green Benefits
Reduced Air Pollutants	6	184
Carbon Dioxide Sequestration	4	122
Compensatory Value of Trees	8,800	278,851
Groundwater Replenishment	10	309
Reduced Energy Use	0	0
Reduced Treatment benefits	5	171
<b>Total</b>	<b>8,825</b>	<b>279,636</b>

<http://greenvalues.cnt.org/national/calculator.php>

average of 20' diameter canopy). The total square footage of each stormwater storage area and proposed trees yield the ecosystem services listed in the table below.

The EPA calculator is one of many ways of hypothesizing about the potential of a site to provide ecosystem services. However there are other tools that can be used to measure the performance of the landscape through testing water, soil, and air quality over time.

### Water

This site has the potential to limit peak stormwater discharges, reducing strain on the grey infrastructure system, erosion, and impact on receiving waterbodies. When added together, the bioretention cells (which rise 1' before overflowing through a weir) in addition to the sunken quad storage area combines to equal a 1/2 acre foot of water storage (shown p. 64). According to Milwaukee Fresh Coast, which provides a simple calculator for green infrastructure performance monitoring, the bioretention cells could removed up to 324 lbs of sediment annually



(<http://www.freshcoast740.com/calculate>).

Water conductivity, a variety of heavy metals, and temperature can be tested with a simple water quality monitoring device shown below. This device could be used at Classroom 2: Water Quality Station 1. Water quality can also be collected in accordance



<https://www.shreveportla.gov/images/pages/N275/dipwide.jpg>

with MS4 regulations, and collected in a sample and sent off to a lab (seen in graphic below). Landscape performance can also be tested through the two monitoring wells located at Classroom 3: Water Quality Station 2. The varying depths allow the user to identify the degree to which water quality improves as it percolates through the subsurface prepared soil and aggregate. Water volume could also be measured



<https://www.shreveportla.gov/images/pages/N275/dipwide.jpg>

using a flow gauge just above the pipe's daylight location (Classroom 2) as well as just after the site of the sunken quad's overflow structure. The flow gauge could electronically record data that can measure the amount of water the landscape is able to absorb, before water is sent back into the grey infrastructure system under the FAC. Next steps for this project would be designing the location of the flow gauges in more detail.

## Soil

Soil should be monitored for pH, organic matter, heavy metals, and phosphorus, nitrogen, and potassium. Compost tea and soil amendments should be monitored over time. Soil can be collected 6 inches below the surface and sent to a Plant and Soil Tissue Laboratory to test the soil surficially. Soil can be monitored long term using a soil auger once a year to document changes in makeup.



left: <http://www.turf-tec.com/TSS3lit.html>  
right: <http://www.thegardenseden.com/wp-content/uploads/2009/10/Soil-Sample-for-Testing.jpg>

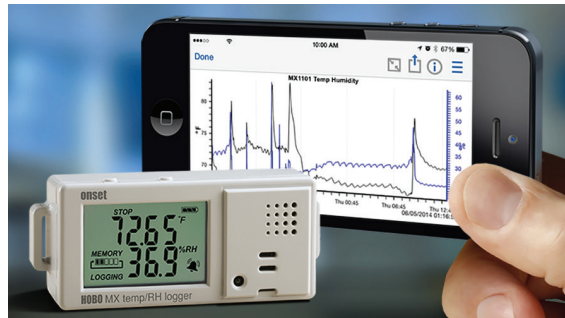
## Air

There are a few simple ways of collecting rough localized air quality and temperature data (i.e. urban heat island effect). The Landscape Architecture Foundation features iTree, a USGS Forest Service



<https://www.itreetools.org/design.php>

software that measures the ability of specific trees to absorb pollution or how the tree may affect energy use. Another strategy for measuring air quality is employing a Smart Temperature gauge, which can digitally log localized temperature changes. This device can be used to compare high-albedo paving against darker color paving, such as asphalt.



[Http://www.concreteconstruction.net/technology/bluetooth-smart-temperature-humidity-data-logger\\_t.aspx](http://www.concreteconstruction.net/technology/bluetooth-smart-temperature-humidity-data-logger_t.aspx)

## Vegetation

The vegetation in the bioretention cells and the pollinator habitat should be monitored over time to see which plants thrive the best from each of the seed mixes. Students from the Environmental Conservation Program as well as Landscape Architecture students and faculty can experiment taking transects of the vegetation. In this way, record of ecological succession can inform adaptive management. Plants that are beautiful and do well in the conditions can be given preference in the beds, as well as provide records for future landscape designs. Plant tissue from the perennial grasses in the stormwater swales

can also be sampled to test whether the plants were successful at breaking down pollutants and removing heavy metals from polluted stormwater runoff. That way, if the plants do have high concentrations of heavy metals, their leaf clippings can be removed from the site and disposed of elsewhere, instead of being returned to the soil. This may also be a method



[Http://www.concreteconstruction.net/technology/bluetooth-smart-temperature-humidity-data-logger\\_t.aspx](http://www.concreteconstruction.net/technology/bluetooth-smart-temperature-humidity-data-logger_t.aspx)

for determining various species' abilities to break down hydrocarbons. Samples could be sent to the UMass Soil and Plant Nutrient Testing Laboratory on campus.

## Conclusion

In conclusion, while it is important design using ecosystem service-based goals, it is even more important to use performance monitoring tools to gauge whether the GSI best-management-practices employed were effective and to what degree. In this way, the systems can be adapted to better fit the site conditions that will allow the system to perform more effectively.

*\*Sustainable Sites credits met: c9.1, C9.2, C9.3*



## OPERATIONS & MAINTENANCE

Once constructed, this landscape design will require some annual maintenance. Because the water system daylighted polluted stormwater runoff, trash and debris will need to be cleaned out of the sediment forebay bi-annually and the first two bioretention cells annually. The sediment forebay has been designed to allow a 6' skipper/ small tractor to access the site on the fire truck/service road and scoop out debris. The bioretention cells may need to be cleaned out by hand. To build biomass and recycle organic matter, the herbaceous vegetation in the bioretention cells and along the stormwater swales should be mowed annually, and the clippings should be neatly tucked under the vegetation to help return nutrients to the soil. Compost tea should be administered annually to restore microbial activity and balance the pH of the soil. Grass should be mown (when dry) in accordance with other campus landscape practices.

### Transdisciplinary Partnerships & Adaptive Management

Throughout the course of reaching out to different stakeholders and experts, it became apparent there is there potential to create partnerships across disciplines at the University.

In the future, Campus Planning will need to take stricter measures to monitor water quality to meet MS4 requirements, and there is currently no protocol to test water quality on campus. The Environmental Conservation Department, which does do some water conductivity testing, could potentially partner with Campus Planning to fund lab equipment necessary to take these kinds of samples. Currently, the samples need to be shipped to West Springfield or further to be processed, and the procedure is costly.

Campus Landscape Services may also consider partnering with Sustainable UMass, who manages permaculture gardens on campus. Landscape Services could work with Sustainable UMass to compost organic matter such as leaves and grass clippings and to use the compost process for compost tea.

Finally, this design has the potential to serve as an outdoor classroom for students from many different programs. The University could offer a single unit course for students from a variety of backgrounds (e.g. Civil Engineering, Environmental Conservation, Landscape Architecture, Architecture, Regional Planning) that would teach students about urban hydrology, maintenance, vegetative transects, adaptive management, and resilience. Because this site is directly across from the new Design Building, the Landscape Architecture and Architecture departments could use the site for a collaborative studio.

Campus Planning and the Landscape Architecture program could work closely together to ensure record keeping regarding the efficacy and short-comings of the green infrastructure systems over time. Water quality and soil chemistry records could help students learn and stimulate new ideas for monitoring systems on campus. In this way, landscape architects can make more confident recommendations regarding GSI best-management-practices.

Had there been more time and resources, a transdisciplinary design team would have enriched the design process. This project is intended to inspire cross-discipline design and planning for future landscape projects, and to also serve as a venue for cross-discipline learning and ongoing, living research.

*\*Sustainable Sites prerequisites and credits met: C8.3, C8.4, C8.5, P8.1*

CHAPTER 6

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CONCLUSION







# CONCLUSION

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The goal of this project is to create a multi-functional landscape that maximizes ecosystem services without compromising the ability to meet the needs of the University of Massachusetts Amherst. This project, based on the Sustainable Sites Initiative V2 guidelines, intends to inspire a more in-depth sustainable planning and design process in hopes of building resilience on campus. The project also offers an alternative adaptive management approach to Campus Planning for future landscape designs.

The goal of this site design is to balance artful rainwater design, simplified geometry, improved circulation, educational opportunities, methods for monitoring, and the campus's need to meet MS4 requirements. In order to create a landscape design that responded to this goal, a literature review covering conventional stormwater management, urban hydrology, sustainable planning and design, green infrastructure, ecosystem services, and performance monitoring was conducted. Three case studies were thoroughly explored to further understand the application of theory into practice. The case studies served as inspiration and design guidelines for this master's project design. Site assessment was conducted to further identify site scale opportunities and constraints to inform the design direction.

This landscape design proposal is more than a localized site design: it is the application of cutting-edge resilience theory into practice and is intended to inspire projects that consider the performance of green infrastructure systems over time. The Sustainable Sites Initiative v2 guidelines, while still evolving, offer a new way of perceiving sustainability and resilience. Sustainability is a non-linear, evolving goal that may inform landscape designs that can be monitored, evaluated, and adapted. In re-conceiving sustainability as a living process and incorporating this vision into our urban ecosystems, such as UMass Amherst, resilience can begin to grow.





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## RESILIENCE AT UMASS AMHERST

A new movement to plan and design monitorable green stormwater infrastructure is beginning to emerge. Faced with the imminent effects of climate change, “sustainability” is becoming a more important part of municipal long-term planning and design strategies. Accumulating evidence demonstrating the myriad of environmental and aesthetic of green stormwater infrastructure (GSI) has given rise to programs that offer sustainability guidelines such as the Sustainable Sites Initiative (SITES) guidelines. SITES encourages resilient landscapes that are designed to: maximize ecosystem service benefits, be monitored for benefits or lack thereof, provide educational opportunities, and improve human health and well-being. In using these wholistic guidelines on a range of projects at multiple scales, municipalities may develop resilient and responsive sustainable landscape practices, in which the ecological management of stormwater plays a critical role. This master’s project proposes that the University of Massachusetts Amherst pilot an ecosystem-service based green stormwater infrastructure demonstration site and educational platform in front of the Fine Arts Center, utilizing the SITES guidelines to explore monitoring methods that could provide useful data for future campus GSI planning initiatives.